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Journal

—OF THE—

American Ceramic Society

A Monthly Journal devoted to the Arts and Sciences Related to the Silicate Industries

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CONTENTS

Editorials: *Page*

Sustained Interest in Ceramics 353
A Question in Regard to Abstracts 354

Original Papers and Discussions:

Elutriation Tests on American Kaolins—Schurecht 355
The Choice of Glass Batches Containing Lime—Turner 379
The Effect of Variation of the Size of the Grog in Terra Cotta Bodies —Clare and Albery 384
Studies in Pug Mill Control—Spurrier 388
Twenty-three Types of Optical Glass—Montgomery 404

Ceramic Abstracts 411

Activities of the Society:

New Members Received during April 433
Meeting of the Pittsburgh District Section 434
Meeting of the Chicago Section 435
Meeting of the Northern Ohio Section 436
Important Actions of the Board of Trustees 436

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JOURNAL
OF THE
AMERICAN CERAMIC SOCIETY

A monthly journal devoted to the arts and sciences related to the silicate industries.

Vol. 3 **May, 1920** **No. 5**

EDITORIALS

SUSTAINED INTEREST IN CERAMICS

It was the writer's pleasure to attend the meeting of the Northern Ohio Section of the American Ceramic Society held at Detroit on April 5th and also the meeting of the Pittsburgh District Section held in Pittsburgh on April 20th, and the spirit of friendly professional interest and coöperation which prevailed at both meetings convincingly indicated the permanent interest which is sustained between the annual meetings or conventions of the Society as a whole.

At the Detroit meeting twenty-five men gathered for conference and discussion, a group as large as some of the very early annual meetings of the Society and of many of the summer meetings. There were men present from Detroit, Flint and Kalamazoo, Mich., Cleveland and Toledo, Ohio, Natrona and Sharon, Pa., Chicago, Ill., and Schenectady, N. Y.

At the Pittsburgh meeting sixty-five men were present at the afternoon session, a number equalling the attendance at the annual conventions up to a very few years ago and equal to the attendance at the summer meetings even up to the present time. At this gathering men were present from Pittsburgh and Beaver Falls, Pa., Columbus and East Liverpool, O., New York City and Schenectady, N. Y., Detroit, Mich., Washington, D. C., etc.

Accounts of these meetings will be found in the usual place in the JOURNAL, but the writer wishes to point out the fact of established continuity of professional interest among the members of the American Ceramic Society. At these inter-conven-

tion group meetings there is naturally less formality in papers and discussions than in the formal annual convention; but the opportunities for personal contact and growth of friendship is greater, and the section meetings will prove of greater and greater value to the individual as time goes on and will promote to a greater degree than any other agency the professional pride and loyalty so essential to the progress of any technical society.

A QUESTION IN REGARD TO ABSTRACTS

In general there are two kinds of abstracts. One gives simply a short description of the article abstracted and makes it necessary for the reader to refer to the original paper for the data presented by the author; the other gives the essential data of the paper. Abstracts of the latter class are necessarily longer than those of the first. Since, as a rule, a large variety of technical journals is not available to our readers, we have felt it incumbent on us to give abstracts of the second class.

This has proven rather expensive, for it costs us about three dollars a page more to secure and print abstracts than to print original papers. Moreover, the printing of abstracts reduces the amount of space that can be devoted to original papers. The question has arisen, therefore, whether it would be desirable to print shorter abstracts and fewer pages of abstracts in each issue of the JOURNAL and more pages of original papers. The JOURNAL is published solely for the benefit of the members of the Society, and the editor would like to have an expression of opinion on this subject from every member who cares anything about the character of the JOURNAL.

ORIGINAL PAPERS AND DISCUSSIONS

ELUTRIATION TESTS ON AMERICAN KAOLINS[1]

By H. G. Schurecht

Introduction

The classifications of clays according to grain size is important in the testing of clays as many physical properties, such as plasticity, dry strength and shrinkage, are to a limited degree functions of the size of grain. The ease of vitrification and fusion are also influenced by fineness of grain. For example, it was found that a substitution of the comparatively coarse North Carolina kaolin for the finer grained English china clay in pottery bodies produces an extremely porous product as compared to the more vitreous ware obtained when the English clay is used. A more complete knowledge of the fineness of our domestic kaolins would be valuable to the potter attempting to use domestic clays in the place of foreign clays.

Chemical analysis and microscopic examination of the different portions separated by elutriation are also important and will in many cases explain differences in the behavior of clays which have the same degree of fineness. This paper, however, is limited to the elutriation of clays with precautions necessary to obtain accurate results with the Schulze elutriator and with results obtained on some domestic kaolins.

Sieve Analysis

The material coarser than 0.074 mm. can easily be separated into different sizes by means of screens. Five hundred grams of sample are crushed to pass a 4-mesh sieve after which the sample is thoroughly blunged with 1000 cc. of distilled water in

[1] By permission of the Director, U. S. Bureau of Mines.

a two-quart "Daisy" churn. The clay is then separated into the following classes by wet screening:

> 20 mesh
20– 65 mesh
65–100 mesh
100–200 mesh

For the above tests, standard Tyler screens were used having the following sizes of openings:

Mesh	Size of opening	
	Inches	Millimeters
20	0.0328	0.833
65	.0082	.208
100	.0038	.147
200	.0029	.074

Elutriation Analysis

Description of Apparatus.—Figures 1 and 2 show the modified Schulze apparatus as used. (1) Shows a gauge to regulate the flow of water; (2) indicates the glass funnel for feeding clay into the elutriator drop by drop; (3) a separatory funnel to introduce ammonium hydroxide into the feed water; (4) distilled water reservoir; (5) overflow tank with a constant water level; (6) can 1, (7) can 2, (8) can 3, (9) can 4 and (10) a jar to catch the overflow from can 4.

The cans are gold plated to prevent corrosion of the copper and to reduce the tendency of the clay to adhere to the metal sides.

The overflow in this apparatus passes over the rim of the cans and is caught in a launder which extends around the outside. In this respect this apparatus differs considerably from the original Schulze elutriator in which the overflow is carried to the next can through a spout in the side of the vessel. The spout tends to form a channel of water which flows comparatively rapid. Allowing the overflow to pass evenly over the sides of rim of the can would tend to overcome this source of error, but owing to the surface tension and adhesion, and the slow rate of flow of the water, the liquid does not overflow evenly in the larger cans. However, it can be made to pass over in four or more places by fastening copper clips on the rims of the cans

which produces a more uniform flow than is obtained by using a side spout as an outlet.

Standardization of the Apparatus.—It is necessary to carefully measure the cross-sectional area of each can. This may be done with calipers or by filling the cone-shaped portions of the can with water and then adding a known volume of water to the vessel.

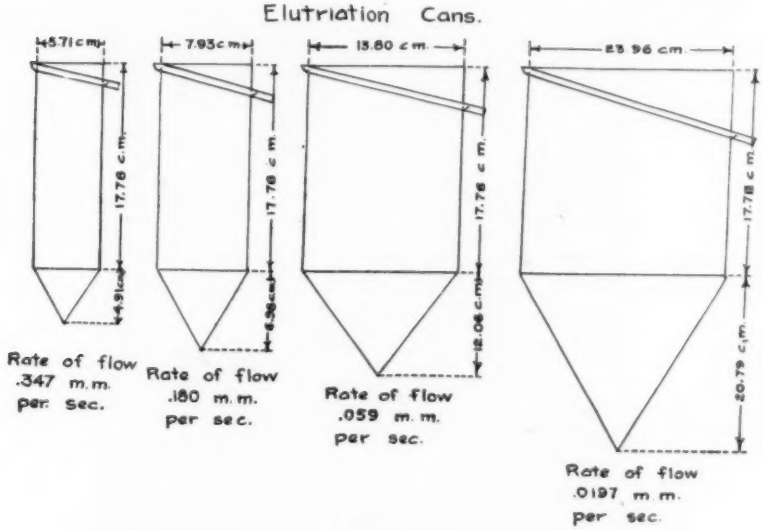

FIG. 1.

The height of the volume of water is carefully measured in the elutriation can and the cross-section obtained as follows:

$$A = \frac{V}{H}$$

A = cross-sectional area. V = volume of water. H = height of water.

Having determined the cross-sectional area of the cans, it is now possible to regulate the velocity of flow as follows:

$$R = \frac{V}{A}$$

V = volume in cu. mm. per sec. A = cross-sectional area of can in sq. mm. R = velocity of flow in mm. per sec.

It is desirable to regulate the apparatus so that can 2 will have a velocity of 0.18 mm. per second as this velocity separates clay-like substance (*i. e.*, material under 0.010 mm. in diameter) from the coarser silt and sand. For example, to determine the volume of flow in order to produce a velocity of 0.180 mm. per

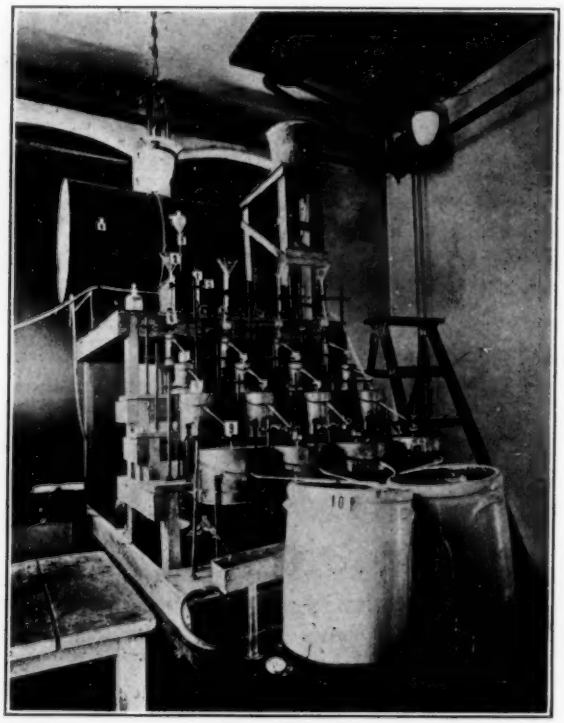

FIG. 2 —Elutriator.

second in can 2 which has a cross-sectional area of 4938.03 sq. mm.

$$0.18 = \frac{v}{4938.03}$$

$v = 888.85$ cu. mm. per sec.

53.33 cc. per min.

This velocity was used in the work, and the following values were obtained for each can:

	Can 1	Can 2	Can 3	Can 4	
Velocity =	0.347	0.180	0.059	0.0197	mm. per sec.

Relation between Velocity of Flow and Diameter of Particles.—Schöne[1] suggested the following empirical formula to calculate the diameter of grains carried off by a given velocity which was found fairly accurate in practice.

$D = 0.0314\ V^{0.636}$.

V = velocity of flow in mm. per sec.

D = maximum diameter of spherical grain-specific gravity 2.65.

For the velocities used in this investigation the diameter would correspond to those given below:

Velocity =	0.371	0.180	0.059	0.0197	mm. per sec.
Diameter =	.0160	.0105	.0052	.0026	mm.

Where the specific gravity is other than 2.65 the formula becomes

$$D = 0.0518 \frac{V^{0.636}}{S - 1}$$

where S = specific gravity of the substance.

The shape of the particle is also important. For example, Rittinger found that for coarse particles the velocity of settle was

$$C \sqrt{D (S - 1)}$$

where C is a constant depending upon the shape of particles and S represents the specific gravity of the substance. For different shapes C varied as follows:

C = 2.73 for roundish grains.

C = 2.37 for long, narrow grains.

C = 1.97 for flat grains.

C = 2.44 for average grains.

We would, therefore, expect large particles of mica, which are flat, to be separated with comparatively small particles of clay which was actually found to be the case.

Clays classified by screening and elutriation may be divided

[1] Schöne, E., "Ueber Schlämmanalyse und einen neuen Schlämmapparat," Berlin, 1867.

into different grades according to their size of grain as was suggested by Seger and Mellor[1] as follows:

Stones—particles above 12.7 mm.
Gravel—particles between 1.27 and 12.7 mm.
Sand—particles between 0.107 and 1.27 mm.
Grit—particles between 0.063 and 0.197 mm.
Silt—particles between 0.010 and 0.063 mm.
Dust or claylike substances—particles below 0.010 mm.

Deflocculation of Kaolin.—The material passing through a 200-mesh sieve is used for elutriation. It is first necessary to deflocculate the particles which are clotted, otherwise a clot or aggregate of fine grains will behave like a large grain and settle in one of the first cans of the elutriator. The aggregates may be separated by thorough deflocculation with NaOH. The point of maximum dispersion is determined by adding 0.02, 0.04, 0.06, 0.08, 0.10, 0.12, 0.14, 0.16, 0.18, 0.20, 0.22, 0.24, 0.26, 0.28 and 0.30 per cent of NaOH to slips containing 100 grams of dry clay and 400 grams of distilled water and determining the point of minimum viscosity. This is done with a flow viscosimeter[2] in the customary manner.

Manipulation of Elutriator.—Before a sample is introduced into the elutriator it is advisable to reduce the rate of flow of the elutriator to about one-third of that desired, which is about 17.77 cc. per minute for the elutriator used in this work. Fifty grams of deflocculated clay are slowly introduced into the apparatus, drop by drop, by means of funnels (2) shown in figure 2. During the period in which the clay is being fed into the elutriator, the velocity of flow should never exceed two-thirds of the maximum, for if the maximum velocity is employed with all of the sample in can 1, the diameter of the material carried away from this can would be too large. The specific gravity of the slip in can 1 should be as close to unity as possible before the

[1] Mellor, J. W., "Jackson's and Purdy's Surface Factors," *Trans. Eng. Ceram. Soc.*, **9**, 106 (1909–10).

[2] Bleininger, A. V. and Hornung, M. R., "Notes on Casting," *Ibid.*, **17**, 330–335 (1915).

maximum flow is used. The diameter of the particles carried away would be approximately as follows:

$$D = 0.0518 \frac{V\ 0.636}{S - L}$$

where L is the specific gravity of the slip.

As elutriation proceeds, considerable NaOH is washed away by the overflow causing an increase in viscosity by flocculation. In order to remedy this evil a dilute solution of ammonium hydroxide is slowly added to the feed water.

In the course of elutriation it was found that fine clay settled along the sides of the cone in the bottom of the elutriator cans and the water coming from the thistle tubes flowed over it as is shown in the sketch (figure 2). It was found almost impossible to get good checks even after a week's time. To overcome this error it was found necessary to stir the residues deposited at intervals. This is done once each day for three days. The flow in the elutriator is stopped, and the clay is allowed to settle for at least 30 minutes, and two inches of water are siphoned from the top of each can. Air is gently forced through the tubes for one minute, which thoroughly stirs up the fine clay. At the end of three days, when the overflow from the last can becomes clear, the residues are removed from the cans, dried and weighed.

It is advisable to let the water from the preceding cans flow against the sides of the thistle tubes of the succeeding cans to prevent the entrapping of air in the tubes which is carried down to the bottom of the can and rising rapidly to the surface introduces a source of error.

The grain size of each residue is measured under a microscope by taking the average of at least 60 grains.

Calculation of Results.—For calculating the average size of grain the following formula[1] was used where d_1 represents the maximum diameter and d_2 the minimum.

$$D = \sqrt[3]{\frac{(d_1 + d_2)_4(d_1^2 + d_2^2)}{4}}.$$

[1] Mellor, J. W., *Loc. cit.*, p. 107.

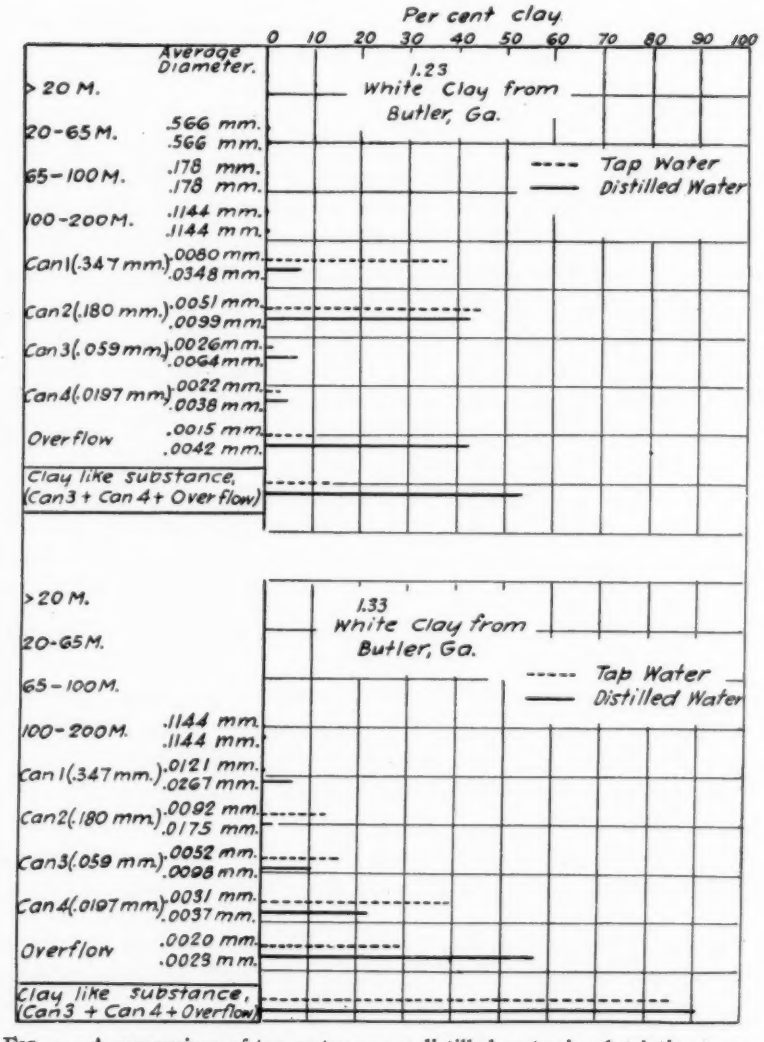
Per cent clay
0 10 20 30 40 50 60 70 80 90 100
Average Diameter.
1.23 White Clay from Butler, Ga.
Tap Water
Distilled Water
> 20 M.
20-65 M. .566 mm. .566 mm.
65-100 M. .178 mm. .178 mm.
100-200 M. .1144 mm. .1144 mm.
Can 1 (.347 mm.) .0080 mm. .0348 mm.
Can 2 (.180 mm.) .0051 mm. .0099 mm.
Can 3 (.059 mm.) .0026 mm. .0064 mm.
Can 4 (.0197 mm.) .0022 mm. .0038 mm.
Overflow .0015 mm. .0042 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)
1.33 White Clay from Butler, Ga.
Tap Water
Distilled Water
> 20 M.
20-65 M.
65-100 M.
100-200 M. .1144 mm. .1144 mm.
Can 1 (.347 mm.) .0121 mm. .0267 mm.
Can 2 (.180 mm.) .0092 mm. .0175 mm.
Can 3 (.059 mm.) .0052 mm. .0098 mm.
Can 4 (.0197 mm.) .0031 mm. .0037 mm.
Overflow .0020 mm. .0023 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)

FIG. 3.—A comparison of tap water *versus* distilled water in elutriation tests.

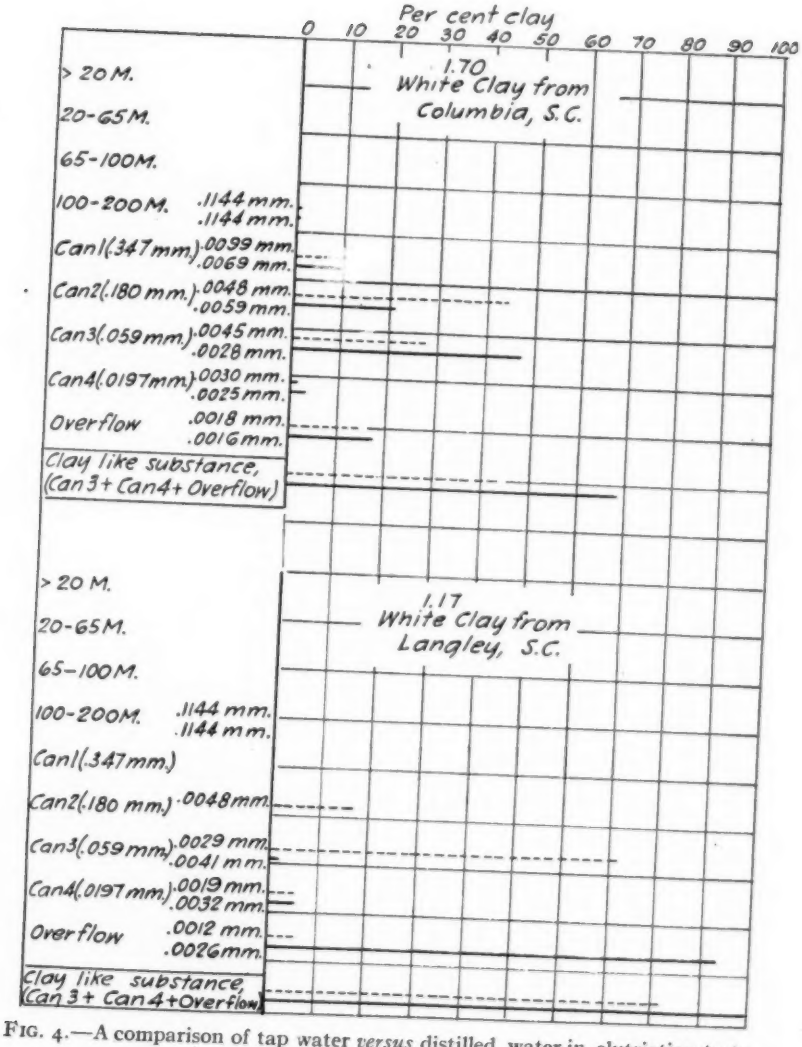
Per cent clay
0 10 20 30 40 50 60 70 80 90 100
1.70
White Clay from Columbia, S.C.
> 20 M.
20-65 M.
65-100 M.
100-200 M. .1144 mm. .1144 mm.
Can 1 (.347 mm.) .0099 mm. .0069 mm.
Can 2 (.180 mm.) .0048 mm. .0059 mm.
Can 3 (.059 mm.) .0045 mm. .0028 mm.
Can 4 (.0197 mm.) .0030 mm. .0025 mm.
Overflow .0018 mm. .0016 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)
1.17
White Clay from Langley, S.C.
> 20 M.
20-65 M.
65-100 M.
100-200 M. .1144 mm. .1144 mm.
Can 1 (.347 mm.)
Can 2 (.180 mm.) .0048 mm.
Can 3 (.059 mm.) .0029 mm. .0041 mm.
Can 4 (.0197 mm.) .0019 mm. .0032 mm.
Overflow .0012 mm. .0026 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)

FIG. 4.—A comparison of tap water *versus* distilled water in elutriation tests.

TABLE 1—RESULTS OBTAINED BY USING COLUMBUS TAP WATER AND DISTILLED WATER IN THE ELUTRIATION OF KAOLINS

T. W.—Tap Water D. W.—Distilled Water

Sample	20 M.	20–65 M.	65–100 M.	100–200 M.	Can 1 Veloc. 0.347 mm.	Can 2 Veloc. 0.180 mm.	Can 3 Veloc. 0.059 mm.	Can 4 Veloc. 0.0197 mm.	Overflow	Can 3+ Can 4+ Overflow	Total surface factor
1.23											
Butler, Ga.											
Per cent											
T. W.....	0	0.12	0.03	0.97	38.43	45.95	1.54	3.16	9.86	14.52	....
D. W.....	0	.12	.03	.97	6.33	37.90	6.91	4.42	43.40	54.73	....
Diameter											
T. W.....	..	.566	.178	.1144	0.0080	0.0051	0.0026	0.0024	0.0015	0.0022	....
D. W.....	..	.566	1.78	.1144	.0348	.0099	.0064	.0038	.0024	.0042	....
Sur. Fact.											
T. W.....	..	.21	.17	8.49	4804.0	9010.0	591.3	1317.0	6547.0	8455.3	22278.17
D. W.....	..	.21	.17	.49	181.0	2818.0	1080.0	1163.0	18080.0	20323.0	23331.81
1.33											
Claymont, Ga.											
Per cent											
T. W.....	0	0	0	0.7	0.15	14.00	16.23	39.73	29.20	85.16	....
D. W.....	0	0	0	.7	6.83	2.20	10.68	22.60	57.00	90.28	....
Diameter											
T. W.....	..	..	..	.1144	0.0121	0.0092	0.0052	0.0031	0.0020	0.0034	....
D. W.....	..	..	..	.1144	.0267	.0175	.0098	.0037	.0023	.0053	....
Sur. Fact.											
T. W.....	..	..	..	6.12	12.40	1522.0	3115.0	12610.0	14600.0	30325.0	31865.5
D. W.....	..	..	..	.12	6.11	125.7	1090.0	6108.0	24780.0	31978.0	32115.9

17.0

Columbia, S. C.

Per cent											
T. W.....	0	0	0	0.2	10.90	44.30	28.60	1.25	14.60	44.45	....
D. W.....	0	0	0	.2	.72	21.30	47.50	3.11	17.25	67.86	....
Diameter											
T. W.....	..	...	...	.1144	0.0099	0.0048	0.0045	0.0030	0.0018	0.0031	....
D. W.....	..	...	...	.1144	.0069	.0059	.0028	.0025	.0016	.0023	....
Sur. Fact.											
T. W.....	..	...	...	1.75	1101.0	9229.0	6356.0	416.7	811.0	14883.7	25215.5
D. W.....	..	...	...	.75	1518.0	3610.0	16960.0	1080.0	10780.0	37820.0	33949.7

1.17

Langley, S. C.

Per cent											
T. W.....	0	0	0	0	0	17.0	72.0	5.9	5.1	82.0	....
D. W.....	..	...	...	....	....	0	1.68	5.61	92.72	100.0	....
Diameter											
T. W.....	..	...	...	....	....	0.0048	0.0029	0.0019	0.0012	0.0020	....
D. W.....	..	...	...	....	....	....	.0041	.0032	.0026	.0036	....
Sur. Fact.											
T. W.....	..	...	...	....	....	.3542	23170.0	1121.0	4250.0	28541.0	32083.0
D. W.....	..	...	...	....	....	....	406.8	1781.0	35660.0	37847.8	37847.8

The Jackson-Purdy surface factor was used to express the fineness of grain which is inversely proportional to the diameter of the particles. For example:

	Per cent	Diam.		Surface factor
>20 mesh	= 38.60	2.00	$38.60 \frac{1}{\frac{1}{2}}$	= 19.30
20–65 mesh	= 7.08	0.566	$7.08 \frac{1}{0.566}$	= 12.51
65–100 mesh	= 0.65	.178	$0.65 \frac{1}{.178}$	= 3.61
100–200 mesh	= 5.80	.114	$5.80 \frac{1}{.114}$	= 30.88
Can 1	= 11.25	.0315	$11.25 \frac{1}{.0315}$	= 349.00
Can 2	= 5.78	.0210	$5.78 \frac{1}{.0210}$	= 375.00
Can 3	= 7.94	.0112	$7.49 \frac{1}{.0112}$	= 708.90
Can 4	= 5.70	.0070	$5.70 \frac{1}{.0070}$	= 812.40
Overflow	= 17.15	.0044	$17.15 \frac{1}{.0044}$	= 3,898.00
			Total surface factor of clay....	6,209.60

Results of Work

Tap Water Compared with Distilled Water in Elutriation Tests.—Figures 3–4 and table 1 show the results obtained by using tap and distilled water in the elutriation of the same clays. It is obvious that the per cent clay deposited in cans 1 and 2 is much greater when tap water is used than when distilled water is employed. This is due to the presence of soluble sulphates and bicarbonates in Columbus tap water which coagulate the finer clay particles, causing them to settle as larger particles. An analysis[1] of the Columbus tap water is as follows:

[1] Analysis was furnished by C. P. Hoover, Chemist of the Columbus Water Softening and Purification Works.

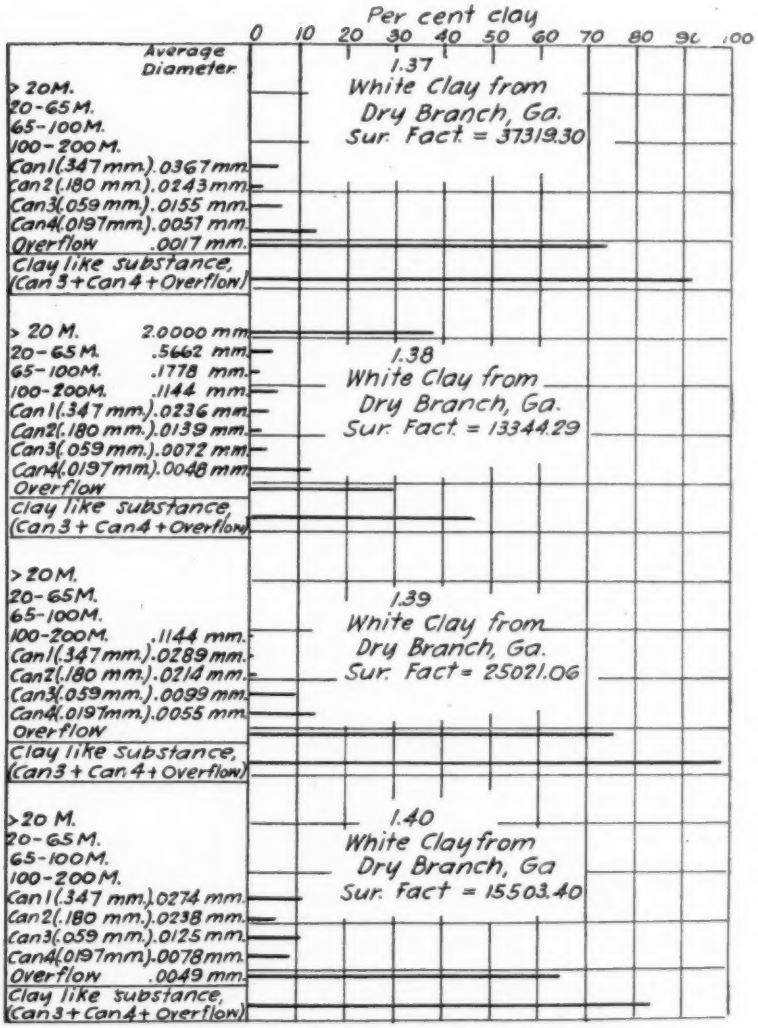

FIG. 5.—Elutriation tests on some Georgia white clays

	Parts per million	Probable hypothetical combination	Parts per million
Total solids	220		
Ignition loss	88		
Alkalinity	43		
Bicarbonates	35		
Normal carbonates	8		
Incrustants	47	Calcium carbonate	43
Total hardness	90	Calcium sulfate	7
Calcium	19	Magnesium sulfate	44
Magnesium	9	Sodium chloride	10
SO_4	6	Sodium sulfate	36
Chlorine	6		
Iron and aluminum	Trace		

The diameters of the particles in cans 1 and 2 separated with tap water are smaller than those of particles separated in the same

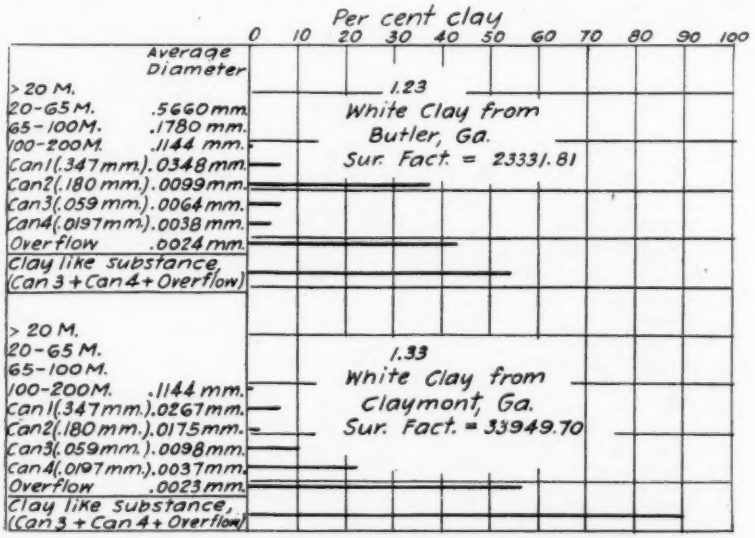
Per cent clay
0 10 20 30 40 50 60 70 80 90 100
Average Diameter
> 20 M.
20-65 M. .5660 mm.
65-100 M. .1780 mm.
100-200 M. .1144 mm.
Can 1 (.347 mm.). 0348 mm.
Can 2 (.180 mm.). 0099 mm.
Can 3 (.059 mm.). 0064 mm.
Can 4 (.0197 mm.). 0038 mm.
Overflow .0024 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)
1.23
White Clay from Butler, Ga.
Sur. Fact. = 23331.81
> 20 M.
20-65 M.
65-100 M.
100-200 M. .1144 mm.
Can 1 (.347 mm.). 0267 mm.
Can 2 (.180 mm.). 0175 mm.
Can 3 (.059 mm.). 0098 mm.
Can 4 (.0197 mm.). 0037 mm.
Overflow .0023 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)
1.33
White Clay from Claymont, Ga.
Sur. Fact. = 33949.70

FIG. 6.—Elutriation tests on some Georgia white clays.

cans with distilled water. This may be due to the fact that a large number of fine particles form floccules which, when highly magnified, appear as a number of small grains instead of one large particle.

TABLE 2—ELUTRIATION TESTS ON GEORGIA KAOLINS USING DISTILLED WATER

Sample	20 M.	20-65 M.	65-100 M.	100-200 M.	Can 1 Veloc. 0.347 mm.	Can 2 Veloc. 0.180 mm.	Can 3 Veloc. 0.059 mm.	Can 4 Veloc. 0.0197 mm.	Overflow	Can 3+ Can 4+ Overflow	Total Surface Factor
1.37											
Dry Branch											
Per cent	0	0	0	0	5.95	2.60	6.60	10.35	74.50	91.45	....
Diameter	...	....	....	....	0.0367	0.0243	0.0155	0.0057	0.0017	0.0076	....
Sur. Fact.	...	....	....	....	162.10	105.40	425.80	1816.00	34810.00	37051.8	37319.30
1.38											
Dry Branch											
Per cent	37.2	4.0	1.7	5.5	3.68	2.00	3.81	12.60	29.45	45.86	....
Diameter	2.03	0.5662	0.1778	0.1144	0.0236	0.0139	0.0072	0.0048	0.0030	0.0050	....
Sur. Fact.	8.60	7.00	9.60	48.08	155.90	143.90	529.20	2625.0	9818.0	12971.2	13344.29
1.39											
Dry Branch											
Per cent	0	0	0	0.12	0.47	1.30	9.24	13.64	75.35	97.85	....
Diameter	...	....	....	.1144	.0289	0.0214	0.0099	0.0055	0.0035	0.0063	....
Sur. Fact.	...	....	....	1.04	16.27	60.75	933.30	2480.0	21530.0	24943.3	25021.06
1.40											
Dry Branch											
Per cent	0	0	0	0	10.85	5.65	10.85	8.05	64.60	83.50	....
Diameter	...	....	....	....	0.0274	0.0238	0.0125	0.0078	0.0049	0.0084	....
Sur. Fact.	...	....	....	....	396.0	237.4	868.0	1032.0	12970.0	14870.0	15503.40
1.23											
Butler											
Per cent	0	0.12	0.03	0.97	6.33	37.90	6.91	4.42	43.40	54.73	....
Diameter	...	.566	.178	.1144	0.0348	0.0099	0.0064	0.0038	0.0024	0.0042	....
Sur. Fact.	...	.21	.17	8.49	181.0	2818.0	1080.0	1163.0	18080.0	20323.0	23331.81
1.33											
Claymont											
Per cent	0	0	0	0.7	6.83	2.20	10.68	22.60	57.00	90.28	....
Diameter	...	....	....	.1144	0.0267	0.0175	0.0098	0.0037	0.0023	0.0053	....
Sur. Fact.	...	....	....	1.75	1518.0	3610.0	16960.0	1080.0	10780.0	37820.0	33949.7

TABLE 3—ELUTRIATION TESTS ON SOUTH CAROLINA KAOLINS USING DISTILLED WATER

Sample	20 M.	20–65 M.	65–100 M.	100–200 M.	Can 1 Veloc. 0.347 mm.	Can 2 Veloc. 0.180 mm.	Can 3 Veloc. 0.059 mm.	Can 4 Veloc. 0.0197 mm.	Overflow	Can 3 + Can 4 + Overflow	Total Surface Factor
1.14											
Langley, S. C.											
Per cent.....	0	0	0	0	12.05	7.40	1.65	10.90	68.00	80.55	....
Diameter.....	..	..	....	....	0.0176	0.0134	0.0100	0.0062	0.0043	0.0068	....
Sur. Fact.....	..	..	....	....	684.7	552.3	165.0	1758.0	15820.0	17743.0	18980.0
1.15											
Langley, S. C.											
Per cent.....	0	0	0	0	10.50	8.60	10.50	6.30	64.10	80.9	....
Diameter.....	..	..	....	....	0.0345	0.0262	0.0128	0.0088	0.0055	0.0090	....
Sur. Fact.....	..	..	....	....	304.4	328.2	820.3	715.9	10630.0	12166.2	12798.8
1.16											
Langley, S. C.											
Per cent.....	0	0	0.19	0.90	4.48	1.69	3.66	32.30	56.80	92.76	....
Diameter.....	..	..	.1778	.1144	0.0276	0.0217	0.0208	0.0073	0.0046	0.0109	....
Sur. Fact.....	..	..	1.07	7.86	162.30	15.45	176.00	4425.0	9808.0	14409.0	1459.57
1.17											
Langley, S. C.											
Per cent.....	0	0	0	0	0	0	1.68	5.61	92.72	100.0	....
Diameter.....	..	..	....	....	....	....	0.00413	0.00315	0.0026	0.0033	....
Sur. Fact.....	..	..	....	....	....	....	406.8	1781.0	35660.0	37847.8	37847.8
1.20											
Langley, S. C.											
Per cent.....	0	0	0	1.00	2.63	11.21	22.74	24.38	38.86	85.98	....
Diameter.....	..	..	....	0.1144	0.0269	0.0176	0.0083	0.0048	0.0024	0.0050	....
Sur. Fact.....	..	..	....	8.74	97.77	636.90	2740.00	5079.00	16190.00	24009.00	24752.41
1.70											
Sumter, S. C.											
Per cent.....	0	0	0	0.2	10.72	21.30	47.50	3.71	17.25	68.46	....
Diameter.....	..	..	....	.1144	0.0069	0.0059	0.0028	0.0025	0.0016	0.0023	....
Sur. Fact.....	..	..	....	1.75	1518.0	3610.0	16960.0	1080.0	10780.0	28800.0	33949.75

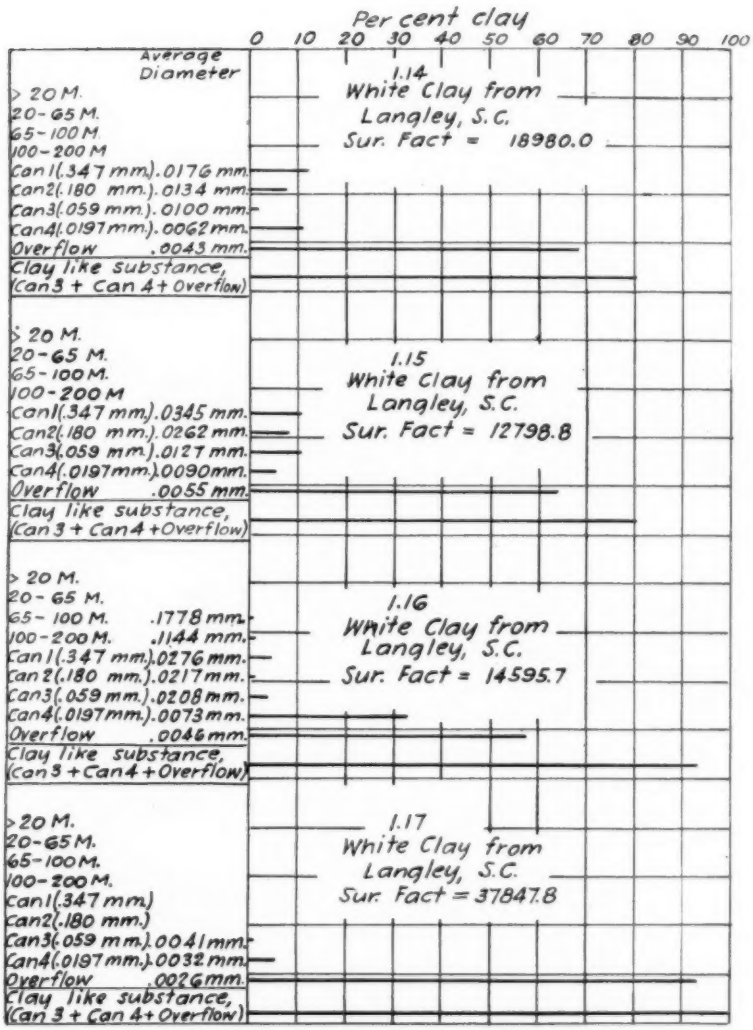
Per cent clay
0 10 20 30 40 50 60 70 80 90 100
Average Diameter
> 20 M.
20-65 M.
65-100 M.
100-200 M.
Can 1 (.347 mm.) .0176 mm.
Can 2 (.180 mm.) .0134 mm.
Can 3 (.059 mm.) .0100 mm.
Can 4 (.0197 mm.) .0062 mm.
Overflow .0043 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)
1.14
White Clay from Langley, S.C.
Sur. Fact = 18980.0
> 20 M.
20-65 M.
65-100 M.
100-200 M.
Can 1 (.347 mm.) .0345 mm.
Can 2 (.180 mm.) .0262 mm.
Can 3 (.059 mm.) .0127 mm.
Can 4 (.0197 mm.) .0090 mm.
Overflow .0055 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)
1.15
White Clay from Langley, S.C.
Sur. Fact = 12798.8
> 20 M.
20-65 M.
65-100 M. .1778 mm.
100-200 M. .1144 mm.
Can 1 (.347 mm.) .0276 mm.
Can 2 (.180 mm.) .0217 mm.
Can 3 (.059 mm.) .0208 mm.
Can 4 (.0197 mm.) .0073 mm.
Overflow .0046 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)
1.16
White Clay from Langley, S.C.
Sur. Fact = 14595.7
> 20 M.
20-65 M.
65-100 M.
100-200 M.
Can 1 (.347 mm.)
Can 2 (.180 mm.)
Can 3 (.059 mm.) .0041 mm.
Can 4 (.0197 mm.) .0032 mm.
Overflow .0026 mm.
Clay like substance, (Can 3 + Can 4 + Overflow)
1.17
White Clay from Langley, S.C.
Sur. Fact = 37847.8

FIG. 7.—Elutriation tests on some South Carolina white clays.

The surface factor obtained when distilled water is used is somewhat larger than that obtained when tap water is used.

It was also found that the results checked much closer with distilled water than with tap water.

A Comparison of the Different Kaolins.—Table 2 and figures 5 and 6 contain the results of tests on Georgia kaolins. In general it might be said that with few exceptions the Georgia white clays

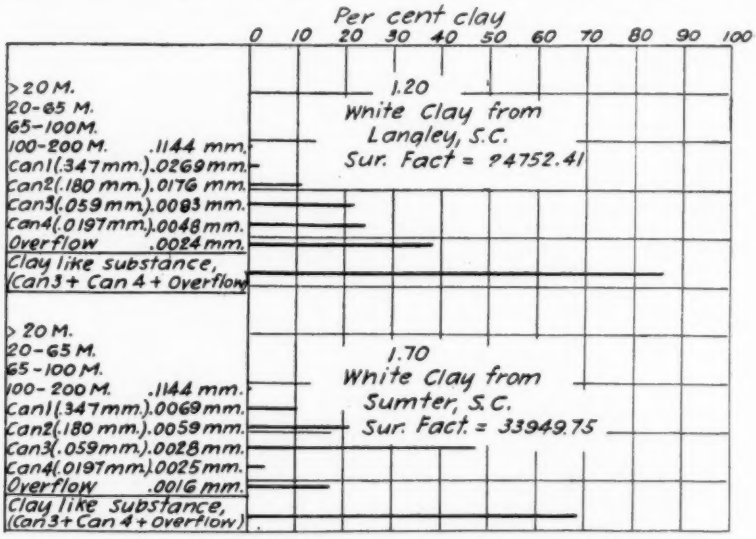

FIG. 8.—Elutriation tests on some South Carolina white clays.

show a comparatively high per cent of clay-like substance, *i. e.*, material smaller than 0.010 mm. in diameter.

Table 3 and figures 7 and 8 show the degree of fineness of South Carolina kaolins and these also appear to have a comparatively high per cent of clay substance smaller than 0.010 mm., comparing favorably with Georgia kaolin in this respect.

In table 4 and figures 9 and 10 are the results of the elutriation tests on other American kaolins. Both North Carolina clays tested show an abnormally low per cent of material below 0.010 mm. The Pennsylvania kaolins have a fairly high content of material below 0.010 mm. diameter.

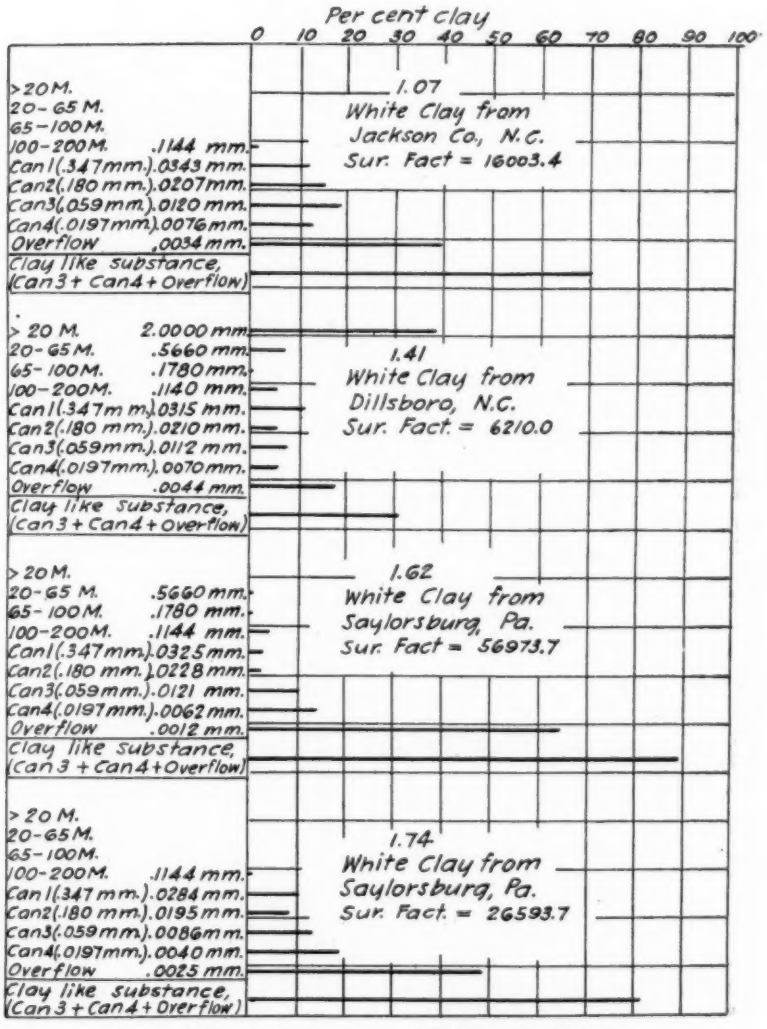

FIG. 9.—Elutriation tests on miscellaneous white clays.

TABLE 4—ELUTRIATION TESTS ON MISCELLANEOUS KAOLINS USING DISTILLED WATER

Sample	20 M.	20–65 M.	65–100 M.	100–200 M.	Can 1 Veloc. 0.347 mm.	Can 2 Veloc. 0.180 mm.	Can 3 Veloc. 0.059 mm.	Can 4 Veloc. 0.0197 mm.	Overflow	Can 3+ Can 4+ Overflow	Total surface factor
1.07											
Jackson Co., N. C.											
Per cent....	0	0	0	1.75	12.00	15.29	18.93	12.25	39.80	70.98	....
Diameter...	...	....	....	0.1144	0.0343	0.0207	0.0120	0.0076	0.0034	0.0073	....
Sur. Fact...	...	....	....	15.30	349.50	738.60	1577.00	1612.00	11710.00	14900.00	16003.4
1.41											
Dillsboro, N. C.											
Per cent..	38.60	7.08	0.65	5.80	11.85	5.78	7.94	5.70	17.15	30.79	....
Diameter..	2.00	0.566	.178	0.114	0.0315	0.0210	0.0112	0.0070	0.0044	0.0075	....
Sur. Fact..	19.30	12.51	3.61	30.88	349.00	375.20	708.90	812.40	3898.0	5419.30	6210.00
1.62											
Saylorsburg, Pa.											
Per cent...	0	0.9	0.66	4.20	2.62	2.94	10.50	14.13	64.40	89.03	....
Diameter..	...	.566	.178	0.114	0.0325	0.0228	0.0121	0.0062	0.0012	0.0033	....
Sur. Fact..	...	1.59	3.71	37.20	80.61	129.00	867.90	2227.00	53670.00	56764.90	56973.7
1.74											
Saylorsburg, Pa.											
Per cent...	0	0	0	0.38	10.06	8.03	13.45	19.58	48.50	81.53	....
Diameter..	...	....	....	.1144	0.0284	0.0195	0.0086	0.0040	0.0025	0.0050	....
Sur. Fact..	...	....	....	3.321	354.2	413.2	1528.0	4895.0	19400.0	25823.0	26593.7
1.58–9											
Hockessen, Del.											
Per cent...	14.50	14.40	2.12	3.91	10.88	5.60	10.95	16.90	20.70	48.55	....
Diameter..	2.00	0.566	0.178	0.1144	0.0280	0.0187	0.0111	0.0077	0.0053	0.0080	....
Sur. Fact..	7.25	25.43	10.66	31.48	388.60	299.50	986.50	2195.0	3906.00	7087.50	7850.42

Table 5 and figure 10 show the results obtained with English china and ball clays. English china clay shows a comparatively high per cent of material smaller than 0.010 mm.; 40.75 per cent was carried away by the overflow. English ball clay contains an extremely high per cent of fine material, 98.55 per

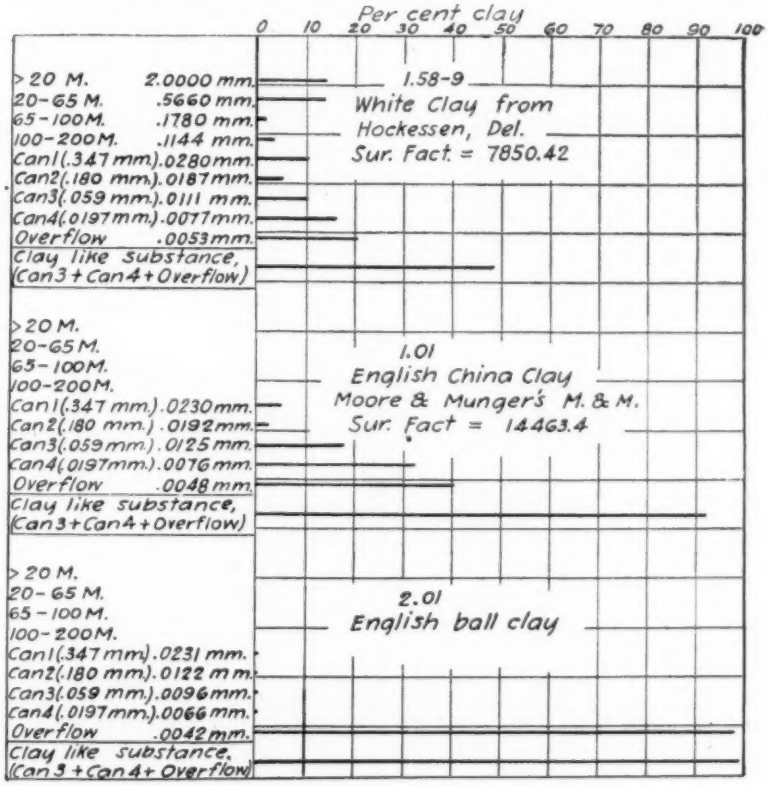

FIG. 10.—Elutriation tests on miscellaneous white clays.

cent being carried away by the overflow. It, therefore, appears that the greater plasticity and bonding strength of ball clays, as compared to kaolins, may be due to their finer grains.

Comparison of Calculated and Observed Results.—Below are given results obtained with varying velocities using both tap and

TABLE 5—ELUTRIATION TESTS ON ENGLISH CLAYS USING DISTILLED WATER

Sample	20 M.	20–65 M.	65–100 M.	100–200 M.	Can 1 Veloc. 0.347 mm.	Can 2 Veloc. 0.180 mm.	Can 3 Veloc. 0.059 mm.	Can 4 Veloc. 0.0197 mm.	Overflow	Can 3+ Can 4+ Overflow	Total surface factor
1.01											
Eng. China Clay											
Per cent	0	0	0	0	5.93	2.70	18.08	32.40	40.75	91.23	...
Diameter	..	...	...	....	0.0230	0.0192	0.0125	0.0076	0.0048	0.0079	...
Sur. Fact	..	...	...	....	257.80	140.60	1446.00	4263.0	8296.0	14005.0	14463.4
2.01											
Eng. Ball Clay											
Per cent	0	0.095	0.030	0.065	0.150	0.200	0.300	0.550	98.55	99.40	...
Diameter	0	.566	.178	.1144	.0231	.0122	.0096	.0066	.0042	....	...
Sur. Fact	..	...	...	....	....	....	.....	...	...	....	...

distilled water; also those obtained by calculation, using Schöne's empirical formula.

	No. of clays tested	Velocities of flow in mm. per second			
		0.347	0.180	0.059	0.0197
Calculated diameters.....	..	0.0160	0.0105	0.0052	0.0026
Diameters obtained with distilled water.....	14	.0177	.0098	.0055	.0033
Diameters obtained with tap water.....	4	.0060	.0038	.0027	.0018

The above table shows that the average diameters obtained with distilled water are fairly close to the calculated diameters. Schöne's formula applies to spherical particles, and the slight difference between the observed diameters and the calculated may be due to the irregular shapes of the clay particles. When using tap water the diameters are much smaller than the calculated diameters.

Summary

The elutriation of kaolins should be carried on with distilled water instead of tap water as the soluble salts in tap water cause the clay particles to coagulate and settle as larger grains.

The residue in each can should be thoroughly stirred each day to overcome the error due to settling of fine particles on the sides of the cone. This may be done by stopping the water flow and gently blowing air through the stem of the thistle tubes. Each sample should be elutriated for at least three days to insure a complete separation, or until the overflow from the last can is clear.

Results check more closely when the residues are stirred at intervals and when distilled water is used in place of tap water.

The clays should be deflocculated and fed into the elutriator, drop by drop, and during this period the velocity of the flow should remain about one-third below maximum.

It was found that the Georgia, South Carolina and Pennsylvania kaolins tested in this investigation contain a high per cent of clay-like substance below 0.010 mm., comparing favorably with the English china clay in this respect.

The North Carolina kaolins tested showed a comparatively low per cent of fine or clay-like substance.

English ball clay contains an extremely high per cent of fine material, 98.55 per cent being carried away by a flow of 0.0197 mm. per second. Only 40.75 per cent of English kaolin was carried off by this velocity. It is evident that the greater plasticity and bonding strength of ball clays, as compared to kaolins, is due largely to their finer grains.

The observed diameters of the particles, as separated with distilled water, correspond reasonably close to the calculated results obtained by using Schöne's empirical formula.

In conclusion, the author wishes to acknowledge his indebtedness to Mr. R. T. Stull and M. C. Booze for the design and construction of the apparatus.

CERAMIC LABORATORIES, U. S. BUREAU OF MINES
MINING EXPERIMENT STATION, COLUMBUS, OHIO

NOTICE.—Further discussion of this general subject is solicited. All communications should be sent to the Editor.

THE CHOICE OF GLASS BATCHES CONTAINING LIME[1]

By W. E. S. Turner

Through the kindness of Dr. Tillotson, the writer has just received a copy of the very interesting and useful report by Dr. Fettke entitled "Glass Manufacture and the Glass Sand Industry of Pennsylvania." In it there is a reference which has suggested this communication in regard to the choice of glass batches, the chief constituents of which are silica (sand), lime and alkali.

On pages 90–95 are quoted a number of batches for various purposes, including table ware, plate glass, lime, flint, and bottle glasses. For the production of the last-named type, the following are quoted:

	American (3)	American (4)	American (4)	American (4)	American (4)
Sand	100	100	100	100	100
Limestone	30	36	32	34	36
Soda ash	27 1/2	38	35	...	...
Salt cake	...	...	...	38	42
Salt	3 1/8	...	...	...	...
Carbon	...	...	...	5	8

It is not easy, unless one is fairly closely in touch with the industry, to know what batches are in common use, and the author of this excellent report was obliged to have recourse for them to early publications as far back as 1883[2] and 1899.[3]

The writer is of the opinion, however, that bottle batches of the type quoted have almost, if not entirely, disappeared from American factories, certainly from those employing automatic or semi-automatic machines. The batches with high lime content are still to be found in use in Europe, since they are eminently

[1] Received Feb. 27, 1920.

[2] Report on the manufacture of glass, by Jos. D. Weeks, 1883, Census Report.

[3] Glass, Robert Linton, "The Mineral Industry for 1889," Vol. 9, pp. 234–263.

suitable for hand-working and are used also in certain types of semi-automatic machines (such as the Horne, the Simpson and the Johnny Bull), which are less highly productive than the modern types. The introduction of machines like the Owens, the Hartford-Fairmont, O'Neill, Millar, Lynch and other types, whether hand fed (in the last three cases), or automatically fed, has not only revolutionized production but has changed markedly the composition of the batch, leading to the introduction of a type similar to that described by Fettke under the term "lime-flint," namely, one similar to the following:

	American (3)
Sand	100
Lime	10
Soda ash	33 1/3
Chili saltpeter	13 1/3

The choice of a glass batch, and in particular of the lime-soda batches, is affected very largely by the mode of working the glass. A glass with a high lime content sets quickly and is, for this reason, suitable for hand-working as the blower does not have to wait unnecessarily after gathering and marvering the metal. Glasses even with higher lime content than numbers 12 and 13 (p. 382) have been used for hand-blowing. Where, however, the glass comes into contact with a mass of iron work which would chill it fairly rapidly, as in machines where the bottle passes through several stations on each of two tables, or on two tiers around a central body, the use of a high lime glass would be either impossible or be attended with difficulty. Moreover, if the machine be fed by an automatic flowing or feed-device, the orifice of the flow would probably tend to become choked as the result of devitrification, a phenomenon which the moderately high lime glasses often exhibit.

For the sake of the mechanical devices, therefore, bottle batches are now much softer, a condition obtained by reducing the lime content very considerably and raising, correspondingly, the alkali content. There are quite a number of advantages. In the first place the high soda, low lime glass melts much more readily than the older batches for hand operation, and production of glass can be speeded up in consequence. Next the glass is softer, and the

bottle can be readily blown up or pressed to its normal shape, whereas when a high lime batch has been used, trouble has frequently been found, especially with narrow-mouth ware, in that the neck near the mouth has not been fully blown up owing to setting too quickly; several bottles and jars can be collected before conveying them to the lehr, whereas the high lime glass must be transferred to the annealing oven much more quickly. For the same reason, the high lime glass could not be so successfully transferred to the lehr by an automatic conveyor because of its rapid setting. Fourthly, the "limeflint" glass requires a distinctly lower annealing temperature than the high lime glass[1] and can therefore be annealed more quickly. A high lime glass has the virtue of smaller expansion for heat than the lime flint glass, but on the other hand has a higher conductivity for heat which causes it to cool rapidly, so that if its temperature falls distinctly below the required annealing temperatures before it is placed in the lehr, strains may be set up which result in cracking. The disadvantage attending the higher coefficient of expansion of the high soda glass is readily avoided by preventing entrance of draught in the lehr.

This account does not quite complete the comparison of the relative merits of the high lime and the lime flint glasses, but it will at any rate serve to indicate the reason why the latter have come into general employment in the bottle industry.

But while the lime flint glass has so many advantages for machine use, it must be borne in mind that the resistance which glass shows toward the atmosphere and to liquids it contains is reduced stage by stage as the amount of alkali is increased. Lime in a well-annealed glass makes very strongly for durability.

The question therefore arises as to how far the softening process can, with safety, proceed, and this question is of importance, not only for bottle glass, but for all other types of lime-soda glass. In order to answer this question, a series of glasses, numbers 1 to 13 (p. 382), were prepared on a semi-commercial scale in the writer's department and were subjected to treatment by boiling water and boiling solutions of strong caustic alkali, sodium carbonate

[1] See English, S. and Turner, W. E. S., *J. Soc. Glass Tech. Trans.*, **3**, 125 (1919).

and hydrochloric acid, for six hours with water and hydrochloric acid, three hours with caustic soda (2N.-NaOH) and sodium carbonate (2N.-Na_2CO_3).

The batch composition of the glass as shown in table 1, numbers 12 and 13, as already stated, being typical bottle batches for hand-working.

TABLE 1

No. of glass	1	2	3	4	5	6	7	8	9	10	11	12	13
Sand	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000	1000
Soda ash	590	560	530	501	471	441	412	383	353	324	295	365	285
Limespar	....	28	55	83	111	139	166	194	222	250	278	500	450
Arsenic	....	....	....	....	....	....	....	....	....	....	....	7	7

Since ordinary commercial materials were employed in the preparation it is desirable to state the actual compositions of the finished glasses. These are shown in table 2.

TABLE 2—COMPOSITION OF THE LIME-SODA SERIES OF GLASSES

Glass	SiO_2	Na_2O	CaO	MgO	Al_2O_3	Fe_2O_3	As_2O_3	Total
1.....	74.05	25.34	0.21	Trace	0.24	0.14	..	99.98
2.....	73.92	23.80	1.50	Trace	.20	.14	..	99.56
3.....	74.08	23.00	2.61	Trace	.21	.15	..	100.05
4.....	74.07	21.50	3.81	Trace	.28	.15	..	99.80
5.....	73.78	20.78	4.50	0.15	.38	.19	..	99.78
6.....	73.18	19.38	6.26	.21	.58	.61	..	100.22
7.....	74.41	17.20	7.45	.24	.30	.40	..	100.00
8.....	74.99	16.00	8.16	.26	.31	.09	..	99.81
9.....	74.96	14.88	9.36	.28	.42	.16	..	100.08
10.....	74.59	14.22	10.38	.30	.45	.21	..	100.15
11.....	74.93	13.02	11.68	.31	.38	.17	..	100.49
12.....	66.71	12.72	18.17	.85	1.41	.31	0.30	100.47
13.....	69.73	11.22	17.38	.55	0.50	.25	.47	100.10

The results of the tests are recorded in table 3, in which the effect of the several reagents is measured by the loss in weight suffered by each 100 square centimeters of the surface.

It will be noted that water is the most corrosive liquid when either no lime or very little lime is present, while strange as it may seem, the strong caustic alkali has least effect.

It will be noted, further, that as the amount of lime is increased, the corrosive action very rapidly falls off. At glass 6, we reach the border line of what may, for ordinary commercial purposes,

TABLE 3—SUMMARY OF RESULTS

(Expressed in mg. per 100 sq. cm.)

Glass	Boiling water Loss in wt.	2N.NaOH Loss in wt.	2N.Na_2CO_3 Loss in wt.	20.24% HCl Loss in wt.
1.....	24000.0	65.2	4618.5	158.4
2.....	335.4	61.1	234.0	71.4
3.....	157.9	60.6	83.8	18.0
4.....	20.9	58.8	45.5	10.2
5.....	10.5	56.0	35.5	6.2
6.....	2.5	53.6	32.3	4.6
7.....	1.9	51.2	30.3	3.5
8.....	1.4	49.4	27.8	2.5
9.....	0.62	46.9	26.7	1.5
10.....	.57	44.6	26.0	1.0
11.....	.53	42.1	25.1	0.85
12.....	.70	46.3	32.7	1.7
13.....	.60	49.8	25.0	1.1

be used with safety. Glass 6 is not quite satisfactory, however. When powdered finely it was found to attract moisture slowly but quite appreciably so that even in article form the same trouble will eventually be discovered.

For general machine use, as well as for hand lime flint operations, glasses 7 to 9 are most satisfactory, 7 containing the lowest limit of lime which is consistent with safety in the above batches. Glasses of this type are commonly in use for Owens machines and for semi-automatic machine with or without automatic feeding devices. On various occasions, however, the writer has found glasses in use made from batches below the lime content of glass 7. Such batches should be avoided.

THE DEPARTMENT OF GLASS TECHNOLOGY
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NOTICE.—Further discussion of this general subject is solicited. All communications should be sent to the Editor.

THE EFFECT OF VARIATION OF THE SIZE OF THE GROG IN TERRA COTTA BODIES[1]

By R. L. Clare and D. F. Albery

Introductory.—This investigation was prompted by the wide variation which occurs in the physical or screen analysis of the ground grog used in terra cotta bodies. We wished to know what effect, if any, this variation had on the physical properties of the body both in the unburned and in the burned conditions.

This grog is purchased in carload lots from jobbers, and little or no control can be exercised over the quality of the material received, either as to composition or hardness. It is simply a carload of saggers or fire brick picked up wherever the jobber finds them and sent to us in open cars for use in a mixture that should be accurately controlled in all its properties.

This material, if hard and dry when ground, will give a high proportion of coarse material and little or no dust, which is material finer than 100 mesh. If the material is soft and friable and wet when received, the resultant grog will show a very high percentage of dust. Both of these extremes occur frequently.

Experimental.—Our idea was to approximate in a mixture these extreme conditions met in factory practice. We therefore made up three bodies the same in all respects except for the variation in the physical analyses of the grog, as follows: One body marked "coarse" containing grog with a high percentage of coarse material; one body marked "medium" containing what we consider a well-balanced grog; one body marked "fine" containing grog with a high percentage of fine material. Each body was made up of two-thirds clay and one-third grog. The physical analyses of these grogs are given below.

We had pressed three pieces each of six different typical shapes from each of the three mixtures, representing the range of simple and difficult material in the factory. These were sprayed, one-half with glaze and one-half with vitreous slip, and burned as

[1] Received Feb. 27, 1920.

PHYSICAL ANALYSES OF GROGS

	Coarse	Medium	Fine
On 12 mesh	0.2	0.1	0.0
On 14 mesh	33.0	11.4	.1
On 16 mesh	4.5	2.9	.1
On 20 mesh	7.8	5.3	1.3
On 40 mesh	33.5	34.3	28.9
On 60 mesh	6.1	13.4	20.3
On 80 mesh	2.6	5.7	8.6
On 100 mesh	2.0	4.4	6.5
Through 100 mesh	10.3	22.5	34.2
	100.0	100.0	100.0

follows: Two pieces of each shape to cone 6 in 110 hours and cooled in 150 hours, and one piece of each shape to cone 6 in 70 hours and cooled in 80 hours. All the pieces were then exposed

TABLE 1

Pressing behavior:
- Coarse mixture — Rather unpleasant to handle, hard to roll, too sticky.
- Medium mixture — Easy to press.
- Fine mixture — Easy to press.

Finishing behavior:
- Coarse mixture — Very hard to finish to a smooth surface, because of excess of coarse grit.
- Medium mixture — Fairly easy to finish.
- Fine mixture — Very easy to finish.

Drying:
- Coarse mixture — This mixture would not dry straight. It seems to "set" quickly and when dry the ashlar pieces would be high in the center and reveal pieces out from the sides. In other words, the mixture did not seem to have the strength to draw the sides or faces "in" when drying, or else from the coarseness of the mixture the drying proceeded too rapidly and the material "set" too quickly.
- Medium mixture — Dried straight.
- Fine mixture — Dried straight.

Cracking:
- The fine mixture was the only one showing any tendency to crack during drying.

Dry shrinkage:
- Coarse mixture — 4.1 per cent
- Medium mixture — 4.7
- Fine mixture — 4.8

to the weather for six months to allow for the development of any defects such as fire cracks, crazing, and so forth.

Careful records were made of the pressing, finishing, drying and shrinkage of each piece, and after burning each piece was tested for sound, warping, cracking, absorption, shrinkage and covering of the glaze. The sound test was made because we found that the mixture with the coarse grit had a very "shakey" or "punky" sound, not indicative of good strength.

Table 1 gives all the data on the unburned pieces, and table 2 on the burned pieces. The results noted are all average readings taken from the eighteen pieces made from each of the bodies.

TABLE 2—RESULTS OF 110-HOUR BURN

	Sound	Warping	Cracking	Absorption* Per cent	Fire shrinkage Per cent	Glaze covering
Coarse body.....	Shakey	None	None	14.2	1.3	Poor
Medium body...	Very firm	Very slight	33% pieces slight cracks	13.2	2.5	Good
Fine body.....	Tight	33% pieces warped	50% pieces slight cracks	12.9	1.8	Very good

* Forty-eight hours' soaking.

Results of 70-Hour Burn.—The pieces from the seventy-hour burn gave practically the same results as shown above except as regards fire cracking or dunting. One of the largest shapes from the medium body and two from the fine body were badly fire-cracked, indicating that this treatment was too severe for pieces of that shape pressed from the bodies noted.

Summary.—In the unburned state the coarse mixture reduced the drying shrinkage, increased the difficulties in pressing and finishing and did not dry straight.

The medium mixture pressed well, finished fairly easily and dried straight without cracking.

The fine mixture pressed well, finished easily, increased the drying shrinkage, and showed a decided tendency to crack in drying.

In the burned state, the coarse mixture was distinctly weak as indicated by the sound test, showed no warping or cracking

comparatively low absorption, low fire shrinkage, and very poor glaze covering.

The medium mixture had good strength, very slight warping and cracking and good glaze covering.

The fine mixture was the strongest as indicated by the sound test, showed considerable warping and cracking, the lowest absorption and the best glaze covering.

The higher fire shrinkage of the medium body is probably explained by the fact that in a well-portioned grog, the fine particles fill the voids between the larger ones, allowing of a closer and more homogeneous body during firing.[1]

The medium and fine bodies are stronger and tighter than the coarse body, undoubtedly because of the greater solution of the fine grit material during vitrification.

The fire cracked pieces in the medium and fine bodies, from the shorter burn, indicate that strains are more liable to occur in the tighter bodies and especially during rapid firing and cooling.

Conclusions.—The results show rather clearly that, if a terra cotta body is to be kept uniform as to its physical properties, the grog size must be controlled. It follows that to control the size you must also control the character and quality of the grog. This is hardly possible when buying grog in the open market as stated in the beginning. The only way this can be obtained is by having grog especially prepared for terra cotta purposes, and ground under stated conditions.

The most suitable material could be selected for the grog, it could be burned to the proper hardness and ground so as to give the best results in the body. This could be prepared at some central plant and each company assured of a steady supply of a uniform material, most suited for its needs. In this manner one source of serious trouble would be eliminated for all time, and a long step in advance taken for the terra cotta industry. The extra cost of the grog prepared in this manner, we believe, would be more than offset by the advantages obtained.

FEDERAL TERRA COTTA CO.
WOODBRIDGE, N. J.

NOTICE.—Further discussion of this general subject is solicited. All communications should be sent to the Editor.

[1] Kirkpatrick, F. A., "Effect of Size of Grog in Fire Clay Bodies," *Trans. Amer. Ceram. Soc.*, Vol. 19, 268.

STUDIES IN PUG MILL CONTROL

By H. Spurrier

The exacting demands made on certain electrical porcelains at the present time call for wonderful uniformity of body both as to the solid constituents and also as to voids due to air or firing vesicles. Granted a body of suitable composition as a whole, it becomes necessary that in order to realize the full benefit of such composition, it is imperative to ensure as complete homogeneity as possible. Unfortunately, ceramic bodies as at present constituted render an ideal or perfect inter-mixture of components entirely impossible with our present modes of preparation of such bodies.

The very common classification of body components into plastics and non-plastics also suggests another classification not so common, to be sure, but nevertheless quite as obvious. If one observes the passage of broken coal, or other similar material, down a chute, it at once becomes evident that the coarser parts are to be found principally congregated in the mid-stream. This suggests that the larger and more angular pieces, on account of their retardation of the general movement caused by the contact of their many points with the walls of the chute, are forced away from the chute wall and toward the center.

The feldspar and flint are the principal producers of friction in a porcelain mix whereas the clay may be looked upon as a lubricant, and in this sense we may classify ingredients of the mix into lubricants and non-lubricants. It is to be remembered that the kaolinite particles are usually exceedingly fine, so fine, indeed, that they largely fall into the ultra-microscopic category.

Now with this conception in mind, if the physical operation of a pug mill be considered, while pugging a small blank, say, of one inch diameter with a bore pin of one-eighth inch diameter, some light may be thrown upon the operation.

The walls of the pug mill and the central bar carrying the bore

pin will be the friction surfaces; and it is here that one would expect to find a disproportionate accumulation of lubricant or clay, resulting in the forcing of the non-plastics, spar and flint, and so forth, into the annulus between the exterior surface in contact with the mill wall, and the interior surface in contact with the pin bar and pin.

Segregation as outlined above, if at all aggravated, would necessarily result in the confusing phenomenon of cracking, warping and internal strain, coupled with physical weakness. For a long time just such segregation has been known to take place and was rendered evident by the examination of microsections taken entirely across the blank. On examinations with about 80 diameters of such a section, one can clearly see the accumulation of clay particles in greater proportion at the outside surface, which was slicked along the pug barrel, and the inside surface, which was slicked along the pin bar and pin.

This phenomenon is influenced by the pressure at which a mill works; and in an effort to determine the relation of working pressure to this segregation, recourse was had to a somewhat novel gauge used to determine the working pressure. In the accompanying sketch (figure 1) *a* is a meter length of barometer tube of 1 millimeter bore made fast to a larger glass tube, *C*, by means of a rubber stopper, *B;* a number eight stopper, *D*, is fitted over the free end of *C* so as to present the larger end to the aperture to be made in the pug mill. The tube *a* is closed at its free end *K;* at a point, *E*, is placed a short column of mercury; and at *F* is a short length of pipe cleaner which acts as a buffer.

The use of this simple and accurate device is obvious. When it is desired to take the working pressure of a pug mill, a hole is bored at the desired spot with a half-inch tap drill and tapped to receive a plug. The apparatus is held or fastened over the tapped hole in the pug so that the hole in *D* fairly covers it and the rubber stopper makes a tight joint. The point *E* of the mercury column being marked off on the glass tube with a wax pencil, the pug mill is started. The clay at once forces its way out of the mill and into the bore of *C*, which must be large enough to allow a column of clay to enter from the test hole without friction. The clay will continue to enter *C* until a pressure has been es-

tablished equal to the working pressure of the pug mill. The effect of this will be to push forward the column of mercury so compressing the air in front of it.

It will at once be seen that owing to the operation of Boyle's law, the mercury column will advance toward K, which position should be marked. The tube a may be graduated for convenience sake. If E advanced half way to K, it would have doubled the pressure in the tube, which means, of course, a pressure of 14.7 pounds per square inch above the atmosphere. In this way by

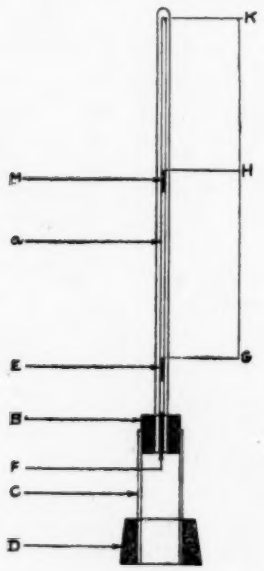

FIG. 1.

boring a number of holes, the working pressure of any part of the mill may be ascertained. Much useful information may also be arrived at concerning the working properties of different clays and clays of different degrees of stiffness.

By this little pressure device it has been shown that the pitch of pug mill blades was not correct, and that parts of the pug were not maintaining the proper pressure increase toward the die.

Another Form of Segregation

There is another form of segregation that vexes the soul of the clay worker, *viz.*, the uneven distribution of air. A single instance, taken from a special experimental pug mill installation, will illustrate this point.

A blank was bored from a diameter of five-sixteenth to one-half inch, and upon this portion a careful air determination made, which showed 11.9 per cent air by volume. The remainder of the blank, from one-half inch internal diameter to the outside, was then tested for air and showed 2.67 per cent by volume. Such differences as these are startling and at once led to a rigid investigation.

It became desirable to be able to determine differences in air content over very small areas, so small that a direct determination of air content became untrustworthy; consequently some other method had to be worked out that would give dependable results on areas separated by about one-sixteenth inch. Two new problems now presented themselves, the first being to produce such samples, the second being to determine the small differences looked for. Small differences in segregation, of the solid constituents, would not disturb the specific gravity a great deal, owing to the fact that the several constituents are so nearly alike in that property, kaolin being 2.5, flint 2.65, and anorthoclase 2.58.

A small difference in air content, however, would have a profound effect on the apparent specific gravity; accordingly the relative specific gravity of the several specimens was determined upon as being probably the most desirable property to investigate.

The Sampling Device

The specimens to be used were cylindrical, about one inch outside diameter, with a central bore of about 60/1000 inch diameter. On such a diameter it was desired to make about six comparisons of density. The blank was cut longitudinally into halves, a length of about one inch of the semi-circular bar was used. The section was placed in a little device carrying a saddle (*2*, figure 2). This in turn was mounted in a frame, *1*, carrying midway and on either side an upright, *3*, which in turn supported a swinging frame, *4*, on the two pivots *5* which were easily withdrawn when

desired. The frame *4* was spanned by a number of cutting wires, *6*, of 0.002 inch diameter. A stop, *7*, served to arrest the movement of the swinging frame at the proper point. On swinging the frame

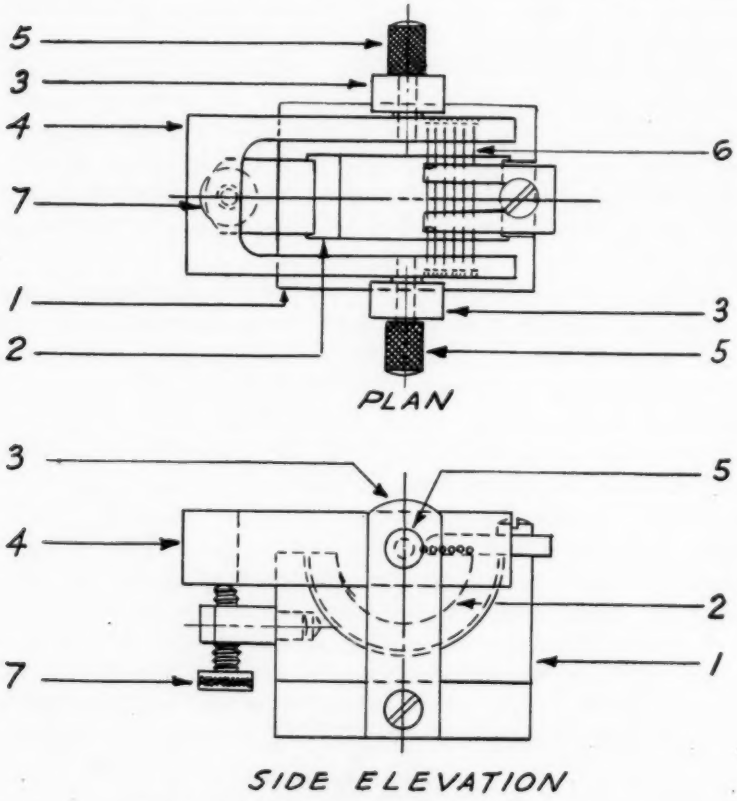

FIG. 2.—Apparatus for sampling clay blanks.

over from side to side the small blank will be cut into as many annuli as there are wires plus one.

Figure 3 shows the result of this operation. It will be seen that the piece may now be parted into leaves that serve for the test described. The attached figures are those used to denote the several sections and are those used as abscissas in the several graphs below. The sections were numbered by minute indentations made with a pointed wire.

Method of Differentiation

To differentiate between the several annuli, produced as above, recourse was had to gravity separation by dense solutions. The specific gravity of pugged clay bodies is usually in the neighborhood of 2; it was, therefore, possible to make a mixture of bromoform, specific gravity 2.8887, and carbon tetrachloride, specific gravity 1.5835, which would serve to float any section desired. Tetrachloride was added from a burette with suitable stirring, so managed as not to distort the specimens. As the solution gradually becomes lighter, a point is reached at which one section

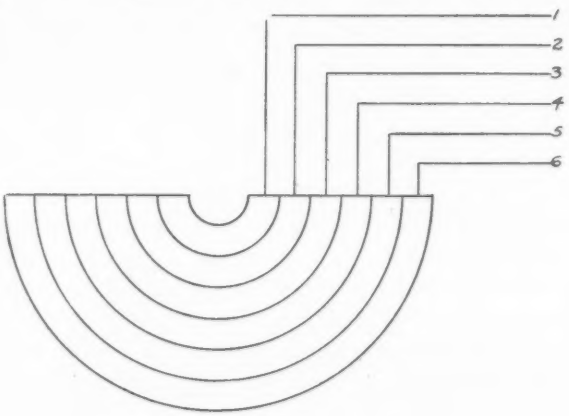

FIG. 3.

by its behavior indicates that it is about to sink; the tetrachloride is now added with considerable caution, care being taken to ensure thorough mixture after each addition.

When a section sinks, its number is recorded and so on until all but one have sunk. It is obviously unnecessary to cause the last section to sink; and moreover this would be objectionable as it is desirable to avoid undue dilution with the tetrachloride, which makes ultimate recovery of the two liquids more protracted.

The data obtained from such tests as above described have been plotted as graphs and when so portrayed and taken in conjunction with other data as to pug mill installation, speed of

pugging, water content, and so forth, bring to light many valuable facts not previously available.

In graph 1 as in all others the ordinates represent the order of sinking of the annuli as the liquid is gradually made less dense by very small decrements in specific gravity; the abscissas represent the various annuli as cut by the sampling device. The same order is maintained throughout.

In this case the center section sank first, meaning of course that it was specifically heaviest. The second section fell third. The third section fell fifth, the fourth sixth, the fifth fourth and the sixth second. The interpretation is that the body was densest in the center, grew regularly less dense until the third section was reached. The rate of decrease in density was reduced between the third and fourth section; from the fourth to the sixth section there was a regular increase in density, the sixth section being next in order of gravity to the first. In terms of air concentration this means that the air content is least at the outer and inner surfaces and increases toward the center, reaching a maximum at the fourth section.

In the second chart are two graphs, being a first and second run on a Crossley pug mill after changing the helix on the horizontal shaft. This illustrates the profound influence on the structure of the clay caused by an apparently insignificant change in the pug mill.

The difference in the two graphs may be due to a number of contributory causes, which is a subject for further experiment. However, it is certain that water content of the clay plays a profound part by its influence on the mobility of the mass. Another point is the great differences in the relation of stickiness to plasticity. Recent work in this laboratory has shown that it is possible to very definitely distinguish between these two properties, and it is hoped in the near future to be able to quantitatively determine and control the relation existing between them.

Chart 3 shows that the less dense area has been pushed a little toward the outside, and that the outer area *6* is rather denser than area *1*, the center.

Chart 4 shows two runs with the same set-up, the first run is essentially similar to chart 3, excepting that the inner areas are a

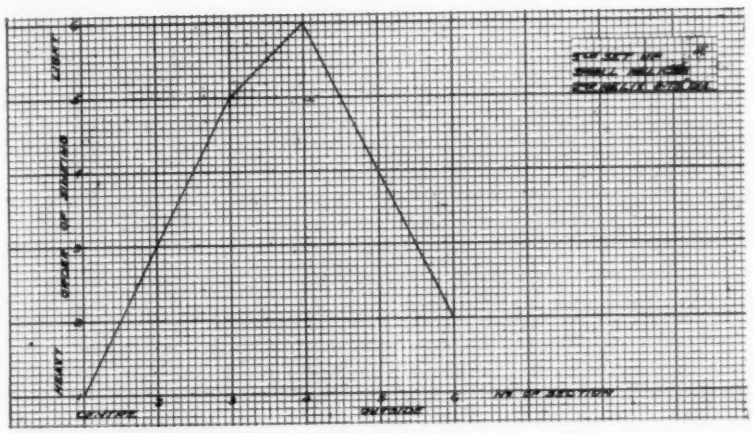

CHART 1.

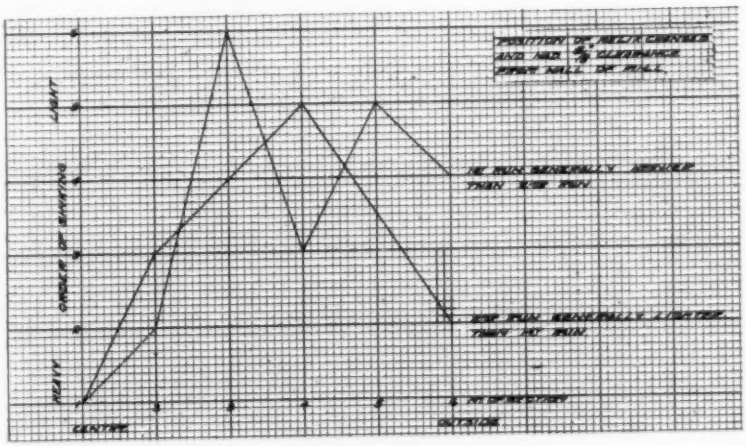

CHART 2.

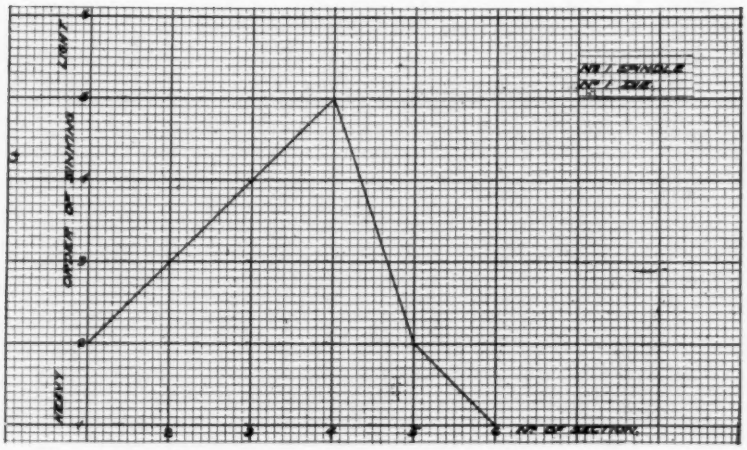

CHART 3.

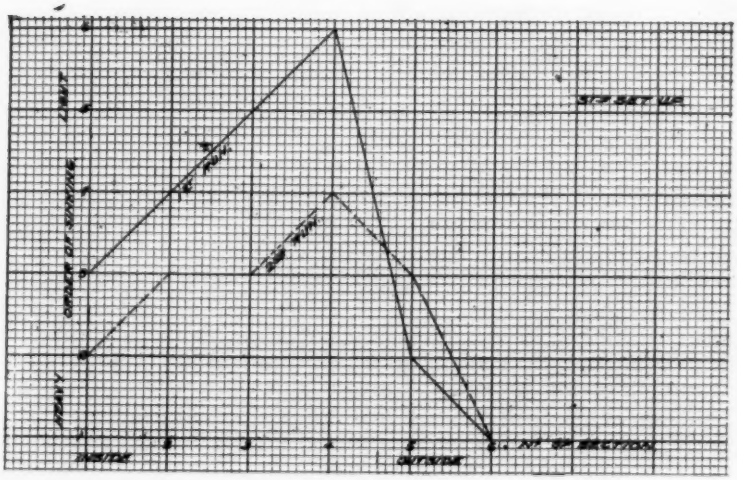

CHART 4

little lighter and the outer areas are a little denser relatively. The second run shows a slight decrease in density from the first to the second area, no change at all between second and third areas, the usual decrease at area four, and increased density from that outward.

Chart 5 is a specimen of clay, that, instead of being pugged, was hand-wedged and put through a die attached to a wad box.

Chart 6 shows two graphs of bodies of different composition, the density variations being essentially alike in the two bodies. These two bodies were hand-wedged and put through a wad box.

Charts 7 and 8 show the influence on the density distribution effected by changing the position of a small obstruction on the bore spindle.

Chart 9. These two charts represent a body of unusual homogeneity, especially is this so of run 2, there being no change in density between the second to the fifth area. The material represented by the second run is probably as good as will ever be obtained from a pug mill and certainly leaves very little to be desired on the score of homogeneity.

Specific Gravity Determinations on Small Samples

Interesting and unexpectedly good as the above results proved, it was still desirable to know something of the actual densities that these small sections showed and to be able to show in figures just what magnitude and relation existed.

Considerable care is necessary in taking small samples upon which accurate work must be done, in order to prevent drying during handling, as the loss of very little more water from one sample than from another might seriously affect the validity of the tests to be made. Therefore, all samples to be used on a given test should be prepared at the same time, and maintained under conditions that prevent change during handling.

In this work it was again necessary to devise sampling apparatus that would give the necessarily small sample of suitable shape and dimensions. Accordingly, the device illustrated in figure 4 was made. The round columnar blank was stood upright upon the piece *1*, the brass top of which was slotted to receive the cutting wires shown in *3* and the piece *2* carrying the cutting grid *3*

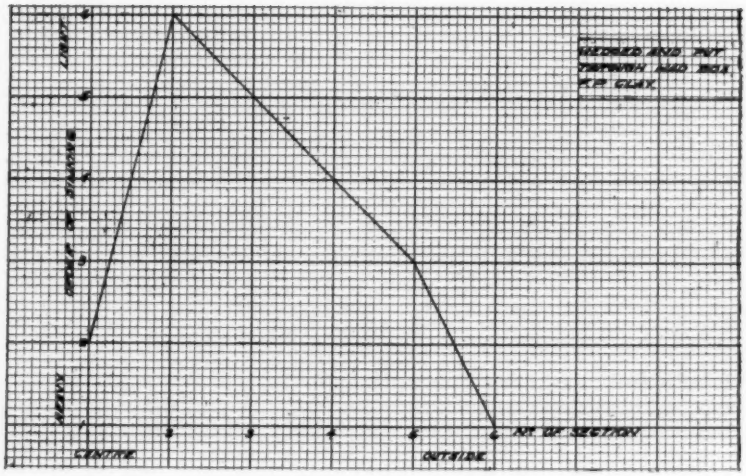

CHART 5.

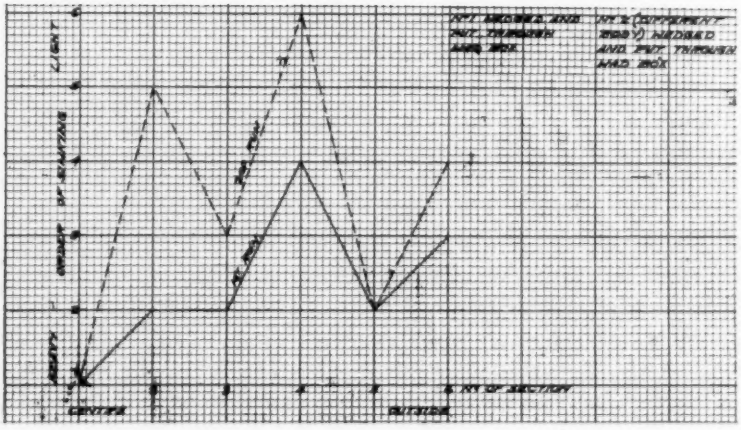

CHART 6

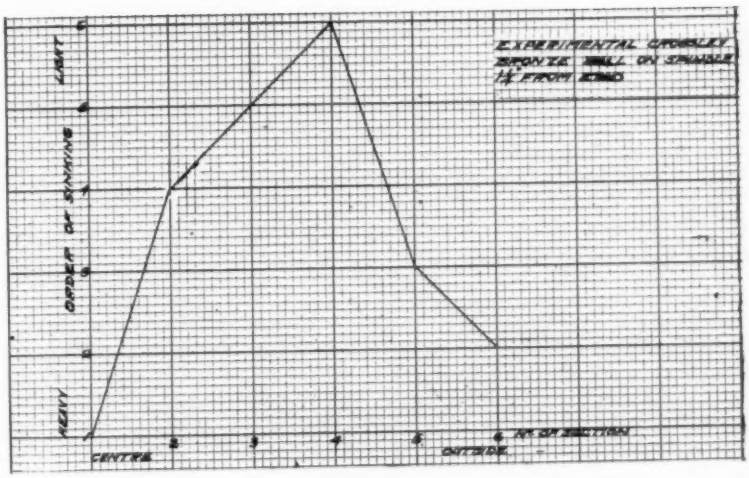

CHART 7.

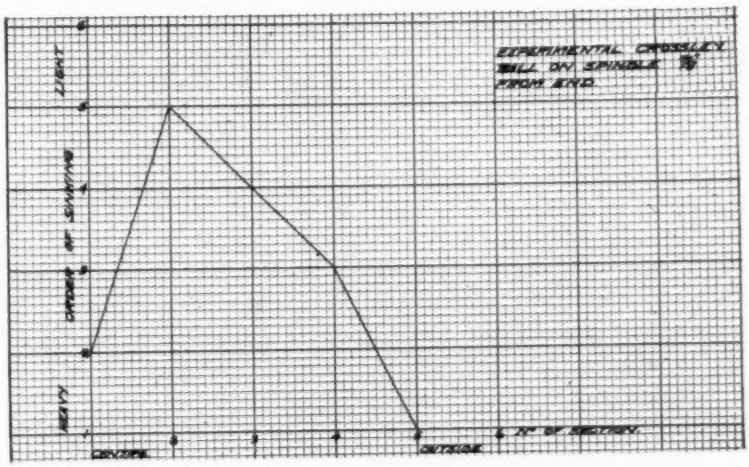

CHART 8.

composed of wires 0.002 inch diameter was slid over it and slowly pressed down until the clay blank was cut entirely lengthwise into square rods of suitable size.

A very delicate volumeter (figure 5) was then made as follows: A piece of glass tube, *A*, just large enough to allow the samples to be slid in without injury was bent into a "U." A length of small bore barometer tube, *B*, of even bore was selected and one end was heated, blown out and drawn down till the walls were of about the same thickness as those of the "U" previously made.

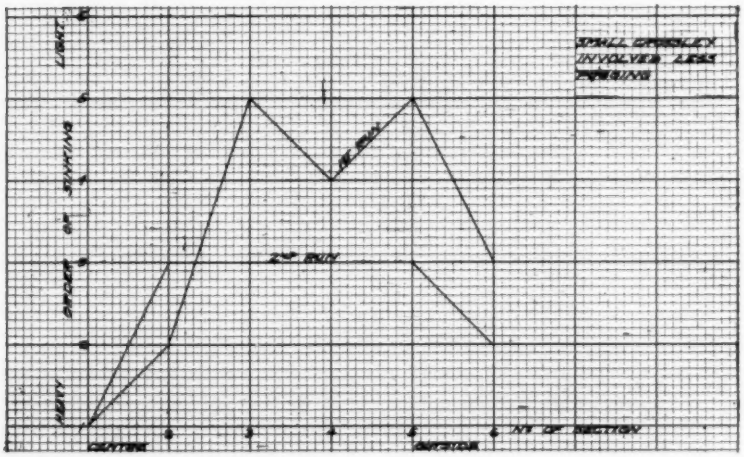

CHART 9.

This end was then cut off evenly and fused to one leg of the "U" at *C*. A line, *o*, was then struck on the upper part of the free end of the "U" and a corresponding mark was etched on the barometer glass tube. The longer tube was then carefully calibrated and graduated for a distance of 2 centimeters in terms of 0.01 centimeters; these fine graduations were sufficiently far apart to enable one to read to 0.0025 centimeter.

In order to use the instrument, it is mounted perfectly upright in a clamp, and filled to the zero mark on the wider tube with kerosene. Capillarity of course makes the kerosene rise above

the zero on the barometer glass tube, which must be read off and used as a correction.

The specimen is carefully weighed in a specially made weighing tube and quickly slipped into the free end of the "U" tube, by inverting the weighing tube (of similar diameter) over it. There

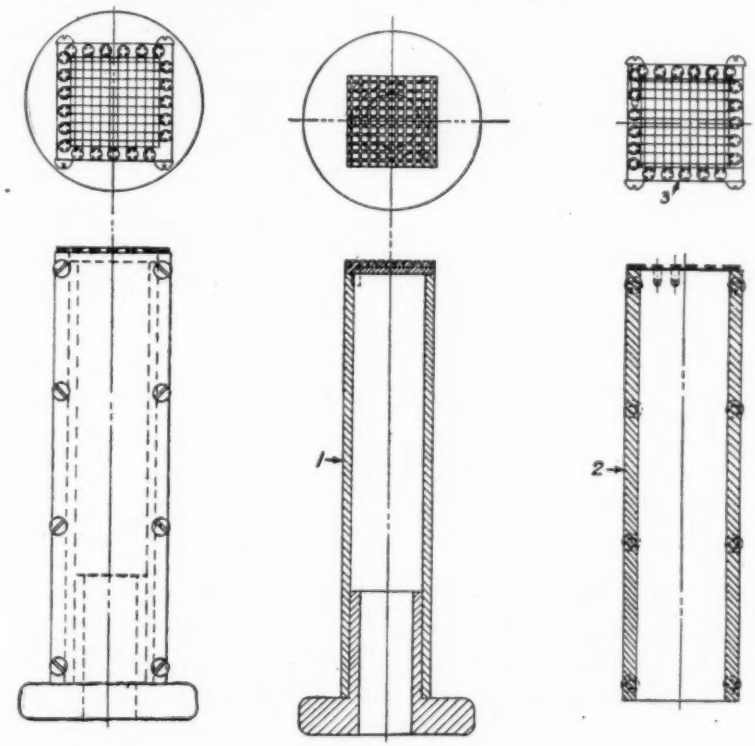

FIG. 4.

is now slipped over the "U" tube a piece of good quality rubber tube furnished with a screw cock. The level of the kerosene is now as rapidly as possible adjusted to the zero mark on the "U" tube by blowing carefully into the rubber tube and closing the screw cock at the appropriate time; this causes the kerosene to rise a considerable height in the graduated tube. The volume is now read off and the correction for capillarity applied. The data for calculating the specific gravity are now in hand.

In using such a volumeter great care must be exercized to avoid change in temperature. No claims for speed or even convenience are made for this piece of apparatus, but it has admirably

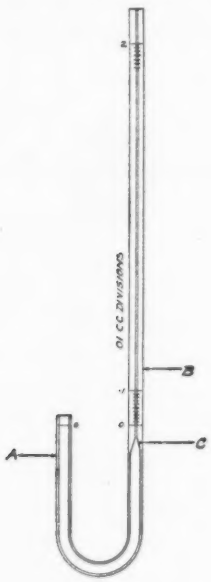

FIG. 5.

fulfilled the purpose of its construction. For good and sufficient reasons the data obtained in practice can not very well be included in this paper, and moreover such figures would not apply to any other than the bodies actually experimented upon.

Summary

1. It has been shown microscopically that pugging causes a segregation of the mineral constituents of a plastic body.

2. A method has been shown for the determination of the working pressure of pug mills.

3. Pugging causes an uneven distribution of occluded air.

4. A method has been developed that shows the actual distribution of air in a plastic body.

5. By plotting data obtained by this method the nature of air distribution is made obvious.

6. The effect of changes in pug mill set-up may at once be properly assessed.

7. The specific gravity of very small sections may be readily obtained.

JEFFREY-DEWITT CO.
DETROIT, MICHIGAN
September 25, 1919

NOTICE.—Further discussion of this general subject is solicited. All communications should be sent to the Editor.

TWENTY-THREE TYPES OF OPTICAL GLASS

By Robert J. Montgomery

Owing to the fact that little or no optical glass was manufactured in the United States before the European war, there is very little known about the subject in this country. Articles so far published have recorded the remarkable advance made in the technique of its manufacture and certain types have been discussed in some detail, but to my knowledge no general survey of the subject has been published. To the average mind the distinction between optical glass and other types of glass is not clear, and the divisions of the field with the limits of optical properties which may be obtained are not fully catalogued. In this paper an effort is made to classify the ordinary types of optical glass and to discuss their composition in general terms.

By the word optical we mean those glasses which are selected for certain purposes because of their behavior toward transmitted light. This behavior is primarily due to the composition of the glass and not to its shape. Practically all of these glasses are silicates. There are a few special glasses containing no silica, as borates and phosphates, but they are of minor importance as far as quantity of glass manufactured is concerned. Each constituent has an effect on the index of refraction and the dispersion of the glass, and these two properties identify the glass as being of a certain type. Glasses not called optical glass are those made to meet some other requirement than that of index of refraction and dispersion. These will include ordinary soda-lime and lead glasses, in which the composition may be changed to obtain satisfactory melting qualities, or thermometer glass, where the coefficient of expansion is important. The main difficulty in making optical glass is in obtaining the required optical properties and at the same time so combining the constituents and handling the material that a good quality of glass will result.

Our information on the subject has advanced to the point where optical properties are relatively easy to obtain, but in some

cases it has been impossible either in Europe or in this country to obtain really good glass. Certain types are of poor color and contain bubbles. Williams and Rand[1] state that the composition of the glasses made by the Bureau of Standards were based on analyses made on glasses manufactured in Europe. In "Jena Glass,"[2] by Hovestadt, a list of 76 glasses is given with dispersion running from 19.7 to 70.0 and index from 1.4967 to 1.9626. The composition of a few of these are given further on in the book but the information is too meager to be of value. In Doelter's "Handbuch der Mineralchemie," E. Zschimmer gives a list of 179 glasses. Both the composition and the optical properties for 87 glasses are listed. A study of this published information, combined with our practical experience in the manufacture of optical glass, brings out the following points: (1) All the glasses may be plotted on coördinate paper allowing the dispersion to be represented by the horizontal distance and the index by the vertical distance. (2) That the glasses fall into natural groups in the field plotted and may be divided into types according to composition. (3) That there are 23 ordinary types of optical glass, each type embracing a number of glasses quite similar in optical properties, composition and method of manufacture. (4) That the composition of the glasses may be divided into two divisions, (*a*) fundamental oxides affecting the optical properties, and (*b*) control chemicals which affect the melting behavior. The fundamental oxides are: SiO_2, K_2O, Na_2O, CaO, PbO, ZnO, B_2O_3, and so forth, while by the control chemicals are meant the proportioning of carbonates, nitrates, chlorides and sulphates or the use of As_2O_3 and Sb_2O_5 to obtain good melting conditions. In some cases the fundamental oxide may be used as a control chemical when the optical properties are not affected by so doing or when the composition may be corrected for the addition of such chemical. Plate 1 shows the fields occupied by the various types of glass with an index 1.45 to 1.800 and dispersion value from 20.0 to 70.0. These are listed in table 1. The ones marked with an asterisk are now being successfully made in commercial quantity in this country.

[1] *J. Am. Cer. Soc.*, **2**, 432 (1919).

[2] English Translation, 26–31.

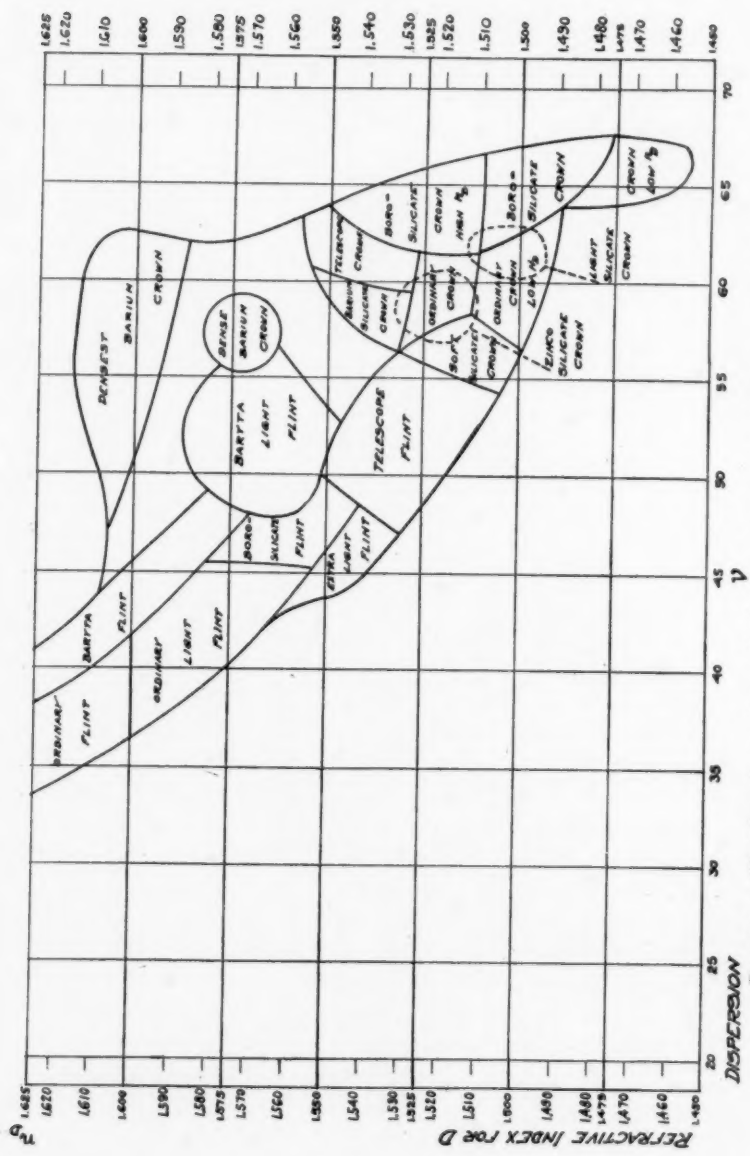

PLATE I.—Showing dispersion and index of refraction of the types of optical glass.

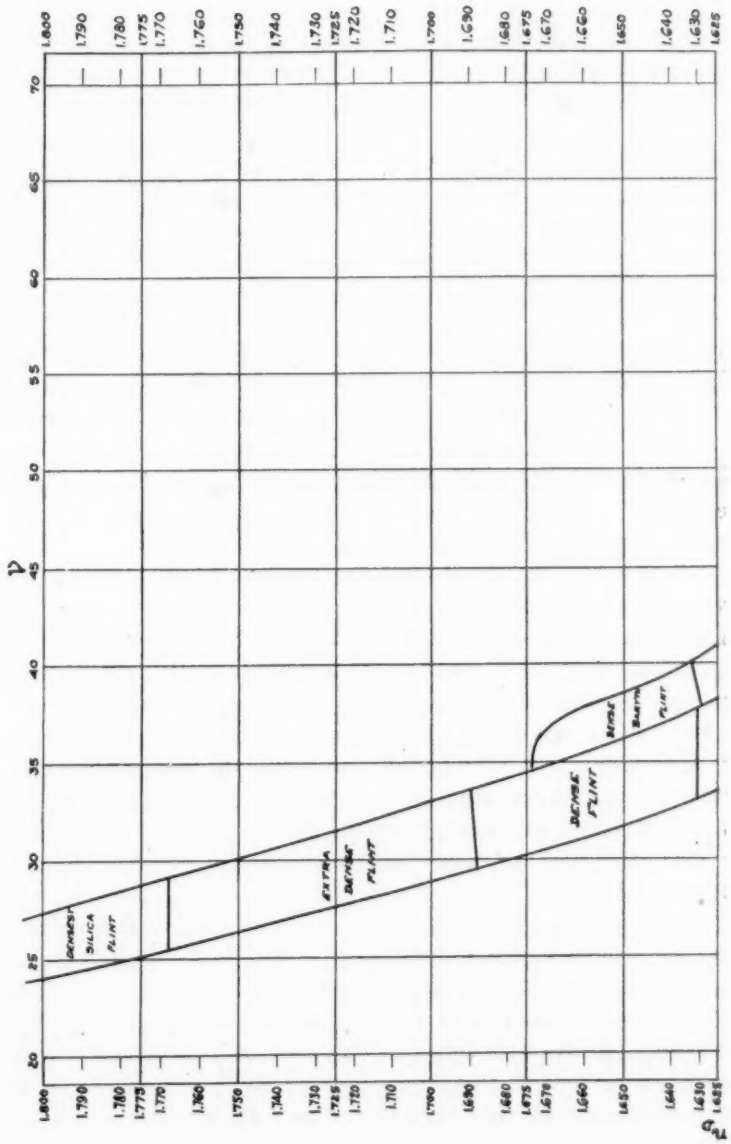
1.800
1.790
1.780
1.775
1.770
1.760
1.750
1.740
1.730
1.725
1.720
1.710
1.700
1.690
1.680
1.675
1.670
1.660
1.650
1.640
1.630
1.625
70
65
60
55
50
45
40
35
30
25
20
ν
DENSE SILICA FLINT
EXTRA DENSE FLINT
DENSE FLINT
DENSE BARIUM FLINT
1.800
1.790
1.780
1.775
1.770
1.760
1.750
1.740
1.730
1.725
1.720
1.710
1.700
1.690
1.680
1.675
1.670
1.660
1.650
1.640
1.630
1.625
n_d

TABLE 1

1 Borosilicate crown	*13 Baryta light flint
*2 Borosilicate crown high N_D	*14 Baryta flint
3 Crown of low N_D	15 Dense baryta flint
4 Light silicate crown	*16 Telescope flint
*5 Ordinary crown	17 Extra light flint
6 Telescope crown	18 Borosilicate flint
*7 Ordinary crown of low N_D	*19 Ordinary light flint
8 Soft silicate crown	*20 Ordinary flint
9 Zinc silicate crown	*21 Dense flint
10 Barium silicate crown	*22 Extra dense flint
*11 Dense barium crown	23 Densest silica flint
*12 Densest barium crown	

It will be noted that we have now made in this country 12 out of the 23 ordinary types of optical glass. Most of the ones which have not yet been made have not been attempted because of lack of demand for the glass. With some we have had difficulty in obtaining quality good enough for commercial purposes, but the experience necessary for the handling of these more difficult types is rapidly being obtained.

A study of the plate shows how little of the field is actually covered by commercial glasses and that very large changes in composition are necessary to change the optical properties to any extent; that is, the index in the first decimal place and the dispersion in the tens place. At the same time it is evident that if the index of refraction and dispersion are to be kept constant for any one glass very small variation in composition will be disastrous. A variation of 0.1 per cent in the amount of the important oxides will affect the index from 0.5 to 1.0 in the third decimal place and the dispersion from 1 to 5 in the first decimal place.

Along the left side of plate 1 is the lead zone which extends from the telescope flint to the densest silica flint. This is almost a single line instead of a zone as given and shows the effect on the index and dispersion of the increase of lead from 10 per cent up to 80 per cent of the batch. This zone may be extended to an index of 1.96 and a dispersion value of 19.7. As we go to the right of this narrow zone barium and zinc are introduced, and we have dense baryta flint with about 10 per cent barium and 5 per

cent zinc, through baryta flint to baryta light flint with 15 per cent barium and 10 per cent zinc. Below these in index are the borosilicate flint, and an extra light flint where boric acid is used in place of barium. The glass containing the smallest amount of lead is the telescope flint.

The lead now disappears and, returning to the barium glasses, which have a rather high index, we have barium silicate crown with about 20 per cent barium, 10 per cent zinc and 2 to 3 per cent of B_2O_3. The barium and B_2O_3 increase as the index increases from 1.540 to 1.61 through the dense barium crown to the densest barium crown, where the barium is about 40 per cent and B_2O_3 10 to 15 per cent. The zinc slightly decreases with these higher index values. There is a middle field which does not seem to be covered by glasses now made. Probably the reason for this is that there is no demand for the glass. In some of the densest barium glasses some Al_2O_3 is often used and may run as high as 8 per cent.

Zinc is largest in amount in the baryta light flint and dense barium crown, being as high as 15 per cent. It decreases in amount as the dispersion increases and is used in the zinc silicate crown and to a small extent (2 per cent) in the soft silicate crown and ordinary crown with low N_D.

The soda-lime field includes the ordinary crown and the ordinary crown of low N_D, while the telescope crown is a soda-lime glass containing B_2O_3 and some barium.

We now come to the glasses containing B_2O_3 in larger amounts. The light silicate crown contains from 5 to 10 per cent and as its field overlaps some of the others it is shown in dotted lines. The borosilicate crown of high N_D contains about 10 per cent B_2O_3 and is rather high in alkali. In the borosilicate crown the B_2O_3 is from 10 to 15 per cent and may contain 2 to 4 per cent of barium or Al_2O_3. The crown of low N_D is higher in B_2O_3 and alkali and lower in CaO.

In making this survey of optical glasses only the general compositions are discussed. There is a natural field in which we normally use each constituent. This does not mean that such constituent may not be used outside of its natural field to control the optical properties or the quality of the melting. The amount

used in such cases is small and does not affect to any considerable extent the type of the glass. When it is desired to develop a new glass with new optical properties its composition can be roughly determined by interpolation between known points in the field, and the necessary chemicals are definitely shown, except in those cases where unusual materials are used.

Special glasses not containing silica, as borates and phosphates, are not considered in this paper; and a few special ones within the field given are left out, as they do not bear directly upon the general subject.

BAUSCH AND LOMB OPTICAL CO.
ROCHESTER, N. Y.

NOTICE.—Further discussion of this general subject is solicited. All communications should be sent to the Editor.

CERAMIC ABSTRACTS

General

PATENTS

Insulator composition. F. RICHARD AND F. M. BRADY. U. S. 1,329,094, January 27, 1920. Silica and carbon with lesser quantities of alumina and ferrous oxide are mixed with water and a binder, the mass shaped and heated first to 100° F. to drive off the water, then to 800° or 9 0° F. to burn out the carbon then the temperature is raised rapidly until contraction ensues and finally the mass burned to incipiently fuse the ferrous oxide.

Heat insulating brick. J. C. EMLEY. U. S. 1,330,249, February 10, 1920. This is a brick particularly adapted for the outer walls of ovens, and having a vitreous or glass face and a heat-insulating backing keyed thereto. The heat-insulating backing consists of infusorial earth and a heat-resisting cement binder.

Basalt, process for the construction of monolithic structures of. F. RIBBE AND P. DHE. U. S. 1,331,377, February 17, 1920. Dams, sea-walls, piers, bridges, fortifications, etc., are made of cast basalt or other volcanic rock. Forms of brick, burned clay slabs, cast iron or very dry cement are erected and the molten basalt poured thereon. The basalt is first heated to quiet fusion and all gas bubbles allowed to escape. In order that the glass be monolithic each successive pouring must be made before the preceding one has cooled too far and thus the molten basalt remelts the surface of the previously cast material and forms an autogenous weld therewith.

Car for tunnel kilns. P. A. MEEHAN. U. S. 1,328,749, January 20, 1920. The body of this car is a single steel casting carrying a floor of refractory material. There are four independently journaled wheels which support the car through depending flanges integral with the body of the car, and open at their bottoms to receive the axles.

Kiln, down-draft. J. ELCOCK. U. S. 1,329,830, February 3, 1920. This is a round down-draft kiln having the usual bags. After the coal is coked in the fire-boxes it is said to be thrust back into the bags and burned. There are two parallel flues which cross the bottom of the kiln and open at intervals through the floor, and four auxiliary flues which connect with these and radiate to four stacks located within the kiln wall.

Kiln, tunnel. G. H. BENJAMIN. U. S. 1,329,745, February 3, 1920. This is a muffle tunnel kiln of a modified Dressler type. The heating zone of the kiln is lined with a series of independent enclosed combustion chambers, which are spaced from the side walls and the roof of the kiln. Laterally movable refractory screens are interposed between these combustion chambers and the ware. Air is allowed to enter the kiln and pass upward on either side of the combustion chambers, and thence downward through the ware. The heating is thus largely by convection. By moving the screens in relation to the combustion chambers the amount of air passing between each screen and its combustion chamber may be regulated, and also the amount of direct radiation through the screen to the ware.

Kiln, tunnel. P. D'H. DRESSLER. U. S. 1,330,433, February 10, 1920. In the Dressler tunnel kiln, the products of combustion pass from the longitudinal combustion chambers in the high temperature zone through conduit extensions in the pre-heating zone. There is often more heat remaining in the product of combustion as they pass through these conduits than is necessary to pre-heat the on-coming ware, and the latter are, therefore, often heated too rapidly. By means of the present improvement atmospheric air in regulated amounts is allowed to mingle with the hot gases at the point where they enter the pre-heating conduits.

Kiln tunnel, combustion chamber. P. D'H. DRESSLER. U. S. 1,330,432, February 10, 1920. This is a modification of the type of combustion chamber disclosed in the patent to Conrad Dressler, U. S. 1,170,428, February 9, 1916. This modification consists in perforating the outer walls of the upper and inner convection ducts which surround the combustion chamber proper. This is done, however, only at the car entrance end of the kiln where the heat of the combustion gases has been largely used up. The object of these perforations is to allow of some direct radiation from the combustion chambers proper to the ware. G. E. MIDDLETON.

Refractories

Brick refractory for boiler furnaces. P. SCHNEIDER. *Tonind. Zeit.*, **44**, 57–59 (1920).—Refractories in boiler furnaces may roughly be divided into two classes: (*a*) Brick which come in contact with hot gases and flames and (*b*) brick which come in contact with hot gases but no flames. Temperatures vary from 900°–1450° C. in different parts of the furnace. The brick in Class A must stand much higher temperatures than those in Class B. Brick having a deformation point of cones 31–33 are required for class A and cone 26 for Class B. Bricks in class A should be burned above cone 10 before putting in the furnace, and should not change more than 2 per cent in volume after they are put in the furnace. Brick with coarse grained grog or flint clay should be used in class A, as these withstand heating and cooling better than the finer grained brick. H. G. SCHURECHT.

Silica brick from the roof of an open-hearth furnace. J. E. STEAD. *Trans. Cer. Soc.*, **18,** Pt. II, 389–398 (1919).—For the purposes of comparison the brick was divided into zones. Zone A was the lower layer, 2 inches in thickness, and was that which had been heated to the highest temperature. A freshly made fractured surface appeared to be quite homogeneous but vesicular. It was light gray in color and closely resembled the fracture of gray blast-furnace slag. Zone B1, 2 inches in thickness, was of a much darker color than zone A, but was free from unabsorbed quartz. Zone B2, $1^1/_2$ inches in thickness, was similar to zone B1, but contained a considerable number of particles of unabsorbed quartz. Zone C, $1^1/_2$ inches in thickness, had a light yellow matrix in which were embedded unabsorbed particles of quartz. Zone D corresponded closely with the appearance of the original brick; it extended from zone C to the outside of the brick, a distance of roughly 5 inches. Microscopic examination, in polarized light, of thin sections cut from the aforesaid zones revealed in zone B the frequently described structure composed of large transparent tridymite crystals; the joints between these crystals were filled with a black opaque substance. In zone A the tridymite had undergone actual fusion, the large crystals being replaced by spherules surrounded by, but not mixed with, the black opaque constituent. On cooling, the molten tridymite changed into cristobalite and, in some places, formed birefringent regions of badly developed tridymite. In zone C the large tridymite crystals continued to appear, but gradually diminishing in size and numbers according as the less heated sections are approached, until in zone D the normal structure of the original brick was encountered. Judging from the analyses it was quite obvious that floating particles of iron oxides, lime, etc., had been absorbed at the lower surfaces of the bricks. Most of these bases, after combination with some of the silica of the bricks, have ascended by capillary attraction to a distance exceeding 5 inches. The maximum amount of iron was in B1, and the maximum of lime was in zone C. As the fusible silicates ascend upwards, the fusing point of the lower end of the brick will be raised, a beneficent arrangement, for, if the flux remained in zone A and did not ascend, the bricks would more rapidly melt away and their life be greatly reduced. A. J. LAMBERT.

Silica materials, notes on new experiments on. A. BIGOT. *Trans. Ceram. Soc.*, **18,** Pt. II, 362 (1919).—Conclusions:—(*a*) Raw silica materials which are too pure are not suitable for the manufacture of silica products, because they fall to powder after having been for variable periods in the Martin furnaces. Chalk flints and many types of quartz are among these too pure materials. (*b*) The silica materials which contain from 2 per cent to 5 per cent of a mixture of clay, iron oxide and a small proportion of magnesia and lime do not fall to powder at high temperatures in the furnaces; they are suitable for the manufacture of silica products if their expansion at 1710° C is not too great. Some quartzitic and quartzose rocks and some dense

flints are included in the class of good raw materials. (*c*) The silica rocks, which contain more than 3 per cent alumina become too fusible after the addition of 2 per cent lime and are not suitable for the manufacture of silica products. A. J. LAMBERT.

Silica products, practical guide for manufacturers of. A. BIGOT. *Trans. Ceram. Soc.*, **18,** Pt. II, 354–361 (1919).—Flint and too nearly pure quartzites are not suitable for the manufacture of silica products because their siliceous elements, becoming friable, lose their crushing strength and are too porous. Bigot studied a certain number of ferruginous sandstones containing from 3 to 8 per cent of iron oxide. After burning at 1710° C dark brown products were obtained, remaining compact even at the end of several days' heating at high temperature. In spite of their color, these rocks are suitable, like quartzites, for the manufacture of silica products. Until to-day no French manufacturer has employed them. To obtain suitable grains and powder, the rocks are first passed through a jaw-crusher, regulated so as to produce pieces small enough. The grinding of these small pieces is done in two pairs of cylinders which revolve in a vertical plane with the same speed in contrary directions, and their separation can be regulated at will. The crushed rocks are brought into the first pair of cylinders, which grind them, giving to the largest grains the desired dimensions; these large grains are accompanied by medium grains and by a little fine. To obtain the necessary quantity of fine a certain proportion of crushed material is caused to pass into the second pair of cylinders with slight separation. Sorting machines separate fine, medium and large; they may be conducted into appropriate silos, whence they are withdrawn for the needs of the manufacture. This grinding process is that which is adopted in works for grinding emery and abrasives; it is simple, it gives angular grains, whatever the degree of hardness of the material may be, it produces the necessary proportion of fine and the sorting machines always furnish the same classification, it is more economical than the use of 5-ton mills installed in certain works, and it abolishes the use of the tube finisher destined to produce silica flour. A. J. LAMBERT.

Zinc furnace refractories, further notes on. J. A. AUDLEY. *Trans. Ceram. Soc.*, **18,** Pt. II, 468–477 (1919).—Ferrous oxide, which is by far the most important of the fluxing materials in the ashes, in zinc retorts, forms with silica first fayalite, Fe_2SiO_4; this, on being absorbed by the muffle body, takes up from the latter more silica to form $FeSiO_3$, the melting point of which is 1500° C, as compared with 1155° to 1075° C for fayalite. Alumina is also dissolved, and such other bases as may be at hand, the product becoming more and more viscous until it finally solidifies. The formation of a glaze or glassy coating on the outside of muffles—from the action of dust and fumes—does not prevent the entrance of furnace gases, or the exit of reducing gases or zinc vapor, but it materially retards such movements and therefore diminishes the formation of zinc dust while helping to increase the yield. The following analyses show the composition of a glaze on the body of a muffle:

SiO_2	Al_2O_3	FeO	CaO	MgO	K_2O	Na_2O	ZnO	PbO	C & S
50.26	31.84	8.85	1.40	0.36	1.09	1.68	3.20	0.28	1.040

Natural gas and Mond gas—in spite of advantages due to homogeneous composition of the gas and the possibility of uniform heating—are by no means ideal combustibles, because they carry no dust with them. When such gases are employed for firing zinc furnaces it is desirable to remedy the deficiency by special glazing of the muffles. A. J. LAMBERT.

Zinc retorts, notes on the microstructure of. ALEXANDER SCOTT. *Trans. Ceram. Soc.*, **18,** Pt. II, 512–515 (1919).—The outer yellowish gray portion appears under the microscope to consist of sporadic quartz grains set in a matrix which is almost opaque. The matrix consists of a clear glass in which are innumerable microlites. Some of the latter appear to be sillimanite, but the majority are hexagonal zinc orthosilicate. As the blue portion is approached the latter increase in number while the amount of tridymite also becomes greater. A microsection of the blue material shows it to be partly crystalline and partly glassy. The original material of the matrix has been completely changed, the alumina having reacted with oxidized zinc to form spinel, while the silica appears partly as tridymite and partly as silicates of zinc and iron. Several syntheses of both ortho- and metal-silicates of zinc are on record, but the evidence regarding the latter is somewhat unsatisfactory. It seems probable that under the conditions obtaining in zinc retorts, zinc oxide reacts with the free silica of the retort to form the orthosilicate and not the metasilicate. In each of the cases described above, the silica was in excess of that required to form the metasilicate, yet the final zinc salt was willemite. The results obtained above are in favor of Vogt's view that the orthosilicates of zinc and iron form two series of mixed crystals, one rich in zinc and crystallizing in the hexagonal system (willemite) and the other, rich in iron and forming orthorhombic crystals (fayalite).

A. J. LAMBERT.

Coke oven walls, the corrosion of. I. The salts extracted from coal by washing. W. G. REES. *Trans. Ceram. Soc.*, **18,** Pt. II, 431–434 (1919).—The salts present in coal probably have a corrosive action on the walls of coke ovens. Rees finds the salts to consist chiefly of sodium chloride and sodium sulphate. They are much reduced by the washing of the coal.

A. J. LAMBERT.

Fire brick, some criticisms by a manufacturer. G. R. L. CHANCE. *Trans. Ceram. Soc.*, **18,** Pt. II, 456–467 (1919).—See *J. Am. Ceram. Soc.*, **2,** 838.

A. J. LAMBERT.

Mica schist for lining cupolas and steel-converters.—P. G. H. BOSWELL. *Trans. Ceram. Soc.*, **18,** Pt. II, 382–388 (1919).—In British practice the material in common use for lining such furnaces as cupolas and steel con-

verts is so-called "ganisters," which consists of a sloppy mixture of broken quartzite or ganister rock and fire clay or ground ganister. Such a mixture is used to a small extent in American foundries, but a large number of works employ a rock belonging to the mica-schist group, which is quarried in Pennsylvania and New Jersey, in each case not far distant from Philadelphia. The rock is fairly hard, and even the foliation surfaces can not be scratched by a knife without some difficulty. Nevertheless, the rock is easily split parallel to the folia and worked into the required shapes. The bulk of the rock is composed of the mineral quartz, the grains being of variable size but not drawn out into lenticles. The rock is thus rather a quartz-schist than a mica-schist. Analysis: SiO_2, 81.58; Al_2O_3, 10.04; Fe_2O_3, 2.24; FeO, 0.32; MgO, 0.19; CaO, 0.22; Na_2O, 0.08; K_2O, 3.38; H_2O^+, 1.74; H_2O^-, 0.27; TiO_2, 0.34. The rock is built by masons into the walls of converters and cupolas, inside the fire-brick casing, in the usual way. It should be set with the cleavage edges, and not the faces forming the inner wall. Nevertheless, where the rock had been so set, the material withstood the effects of hot metal.

A. J. LAMBERT.

Cement, refractory. *Tonind.-Zeit.*, **44**, 32 (1920).—The cementing action of refractory cement is not similar to that of Portland cement but its cementing action is due to the partial fusion of the mortar which in combining with the brick hold the brick together. H. G. SCHURECHT.

PATENTS

Refractory lining. W. G. LAIRD. U. S. 1,328,380, January 20, 1920. Fire brick made of fire clay and silica may be highly refractory provided fluxing materials such as ash, alkalis, etc., do not come in contact with them at high temperatures. So-called condensed refractories such as carborundum-fused alumina, magnesia, etc., are resistant to chemical fluxing action but are very expensive. It has been attempted to bond a facing of these latter materials on a fire-clay backing, but differences in co-efficients of expansion have caused these to fail. This inventor claims to have attained success by surfacing a fire-brick furnace wall with slabs of carborundum held in place by means of locking blocks of the same material placed between the ends of the fire brick.

Refractory material and process of making it. T. SHEARD AND H. E. WETHERBEE. U. S. 1,329,434, February 3, 1920. A refractory composition is made from dolomite which is said closely to approach Austrian magnesite in composition and quality. The dolomite is crushed and burned in a rotary kiln to convert it into a mixture of calcium and magnesium oxides. The next step is the elimination of more or less of the calcium oxide, and to this end the calcined mixture is treated with HCl, or better with the waste liquor from galvanizing pickling vats, such liquor consisting of a relatively dilute solution of iron chlorides, both ferrous and ferric, together with a little free HCl.

Considering the iron as ferrous the reaction is as follows: $MgO.CaO + FeCl_2 + H_2O = Mg(OH)_2 + Fe(OH)_2 + CaCl_2$. The calcium chloride is removed centrifugally and the residue formed into bricks or nodules and burned to about 1500° C.

It is not necessary for some purposes to remove all of the calcium oxide, and for furnace floor and wall linings a mixture comprising substantially 80 per cent magnesium oxide, and 20 per cent calcium oxide has been found satisfactory.

Refractory compounds, process of producing. U. S. 1,330,263, February 10, 1920. Calcined magnesite, an iron compound and silica are pulverized, mixed and calcined in a kiln, to cause the oxides of magnesium and iron to unite. A basic refractory is produced. G. E. MIDDLETON.

Glass

Annealing and characteristics of glass, concerning the. A. Q. TOOL AND J. VALESAK. Bur. of Standards, *Scientific Paper* **358.**—The characteristics involved in annealing were investigated for a number of glasses of different composition, chiefly those produced by the Bureau of Standards at Pittsburgh. *Annealing temperature by optical method:* This method consisted of observing samples of the glass placed between crossed nicols and heated in an electric tube furnace. The double refraction remained quite constant until the "annealing temperature" was reached. At this temperature a perceptible diminution in the intensity of the light began, showing that the stresses were already relaxing at a fairly rapid rate. As the temperature rose still higher the intensity decreased at a constantly increasing rate until it had practically vanished at the "upper limit." It is advisable to use well annealed or only slightly strained specimens in these tests. The greater part of the stresses will then be due to the temperature gradient produced by heating. *Measurements of retardation:* The curves obtained indicate that the double refraction shows a distinct rise to a maximum just before it begins to fall rapidly. It crosses to negative values for a time, and then, after reaching a minimum, gradually approaches zero again. Other manifestations of this interesting transformation that takes place near the annealing temperature range in glasses lie in an apparent increased absorption of heat and in increased thermal expansivity. *Critical Range:* To determine whether any heat effect accompanied the softening of the glass, a differential thermocouple method was used. In every case the glass shows an increased absorption of heat on heating, while on cooling there is evidence of a decrease in evolution of heat in passing through the same region. These effects are not necessarily true endothermic or exothermic transformations as these terms are usually interpreted. The heat absorption and the rapid softening of the glass are allied phenomena, and it is possible to determine the annealing range by means of the heat absorption. The curve for thermal expansion gives, therefore, as Peters has shown (C. G. Peters, Meeting of American Physical Society,

Class	Boiling H_2O	H_2O at 183°	2*N* NaOH	*N*/10 NaOH	2*N* Na_2CO_3	Boiling HCl
	S (0.5)	O (15.4)	G (235.8)	Q (41.0)	D (74.1)	S (0.7)
	....	F (29.2)	P (237.3)	G (46.0)	Q (75.9)	O (1.5)
	A	E (32.4)	.....	T (46.5)	.....	R (2.0)
	G (0.8)	B (34.8)	T	F (52.4)	E	P (2.8)
	C	G (35.0)	D (239.4)	L (53.0)	P (78.0)	M (3.0)
	O	C (38.6)	.....	D (53.9)	.....	L (3.1)
	....	A (39.8)	Q (242.9)	N (56.3)	C (83.2)	N (3.2)
Good.....	L	D (41.0)	S (273.6)	B (60.0)	F (83.4)	T (3.4)
	F (0.9)	L (60.6)	B (276.5)	E (61.8)	L (87.7)	Q (4.3)
	....	N (75.5)	N (280.9)	C (62.1)	B (90.3)	G (5.1)
	E (1.0)	Q (78.6)	E (283.8)	M (64.2)	A (92.2)	J (5.4)
	N (1.1)	P (85.9)	L (287.1)	A (64.4)	T (96.8)	I (5.8)
	....	.....	R (289.1)	P (65.4)	.....	D (7.2)
	P	.....	K (290.0)	.....	.....	H (8.0)
	B (1.2)	.....	C (292.4)	.....	.....	E (8.3)
	M	.....	M (294.0)	.....	.....	C (9.7)
	....	.....	F (312.5)	.....	.....	.....
	Q	.....	.....	.....	.....	.....
	D (1.4)	.....	.....	.....	.....	.....
	T	.....	.....	.....	.....	.....
	I (2.8)	T (124.8)	I (343.4)	R (84.4)	G (108.1)	B (12.5)
Moderate.....	R (3.7)	M (204.8)	O (355.2)	I (90.6)	N	.....
	U	.....	J (364.0)	O (92.2)	.....	.....
	....	.....	A (387.6)	S (98.3)	M (145.4)	.....
	....	.....	.....	.....	O (153.3)	.....
	K (5.5)	R (994.6)	H (470.3)	J (111.3)	I (263.3)	F (18.0)
Bad.....	J (6.2)	I (1435.0)	.....	H (136.8)	J (364.3)	A (31.8)
	H (14.4)	J (1924.4)	.....	.....	S (397.0)	.....
	....	H (3470.0)	.....	.....	R (422.5)	.....
	....	S (4917.3)	.....	.....	H (600.7)	.....

	....	S (4917.3)	.....	.....	H (600.7)	.....					

ANALYSES OF THESE GLASSES

	K	L	M	N	O	P	Q	R	S	T	U
SiO_2.....	74.32	68.03	69.84	68.58	80.62	66.62	66.80	75.90	76.10	67.42	76.20
As_2O_5.....	Nil	Nil	Nil	0.18	0.66	Nil	2.05	Trace	Nil	Nil	Nil
Sb_2O_3.....	Nil	0.45	1.00	Nil	Nil	1.80	1.29	Nil	Nil	0.65	0.30
Al_2O_3.....	2.35	2.62	0.96	2.90	2.00	3.11	2.54	0.24	0.20	.65	.30
ZnO.....	Nil	7.39	3.80	3.60	Nil	8.20	9.75	Nil	Nil	8.12	Nil
CaO.....	3.67	0.80	1.69	2.65	0.22	0.20	1.73	8.73	6.30	3.14	8.97
MgO.....	0.11	3.41	6.25	2.53	.29	3.29	2.60	0.15	.29	4.50	Trace
K_2O.....	1.38	0.30	0.70	1.29	.61	1.40	1.75	7.84	5.60	3.06	7.62
Na_2O.....	17.56	11.18	11.25	10.01	3.83	11.76	7.40	7.29	11.16	9.92	7.07
B_2O_3.....	Nil	5.81	4.02	8.0	11.90	3.74	4.13	Nil	Nil	2.35	Nil
MnO.....	0.10	Trace	Trace	Trace	Trace	0.13	Trace	Trace	0.10	Trace	Trace
Fe_2O_3.....	.14	0.20	0.34	0.20	0.16	.14	0.17	0.10	.14	0.21	0.14

Baltimore, December, 1918), another method of determining the highest advisable annealing temperature. *Annealing time:* The results outlined herewith all point to the desirability of as low an annealing temperature as is consistent with the efficient and rapid removal and prevention of permanent stresses. The rate of the relaxation of the stresses in the glass was determined at different temperatures by the use of two methods: first, by measuring the rate of deformation of loaded strips of rods; and, second, by determining the rate at which the double refraction in unannealed glass disappeared.

A. J. LAMBERT.

Chemical glassware, the resistant properties of. A. The resistant properties of some types of foreign chemical glassware. J. D. CAUWOOD AND W. E. S. TURNER. *J. Soc. Glass Tech.*, **2**, 219–35 (1918).—**B. Further Investigation on Chemical Glassware.** CONSTANCE M. M. MUIRHEAD AND W. E. S. TURNER. *J. Soc. Glass. Tech.*, **3**, 129–31 (1919).—Resistance to attack by various chemical reagents was measured in the case of 1 Japanese (K), 6 American (L, M, N, O, T, V), 5 German glasses (P, Q, R, S, U). The samples were as follows: K = Japanese; L = Nonsol; M = Insolo; N = Fry; O = Pyre; T = Insol; V = Macbeth-Evans; P = Resistance "R;" Q = Kohn-Ehrenfeld; R = Kavalier; S = German, unmarked; U = Zsolua. The results of the various tests are shown in the following table in which the losses are given in terms of milligrams loss in weight per square decimeter of surface. These columns are arranged in the order of resistance to attack with the most resistant glass at the top.

These results show seven glasses in the "good" class in every test. These include three British (C, D and E), two American (L and V), and two German (P and Q). Figures on the British glasses were given in an earlier article—see *Chemical Abstracts*, **12**, 212–13 (1918). The general conclusions: (1) the zinc-aluminum borosilicates or aluminum borosilicates, especially the former, are usually the best glasses for chemical glassware, although the Macbeth-Evans glass is a zinc borosilicate with low alumina; (2) soda-lime glasses show fair resistance to water and to dilute alkali, good resistance to strong caustic alkali, poor resistance to sodium carbonate and excellent resistance to acids. This makes the soda-lime glass especially valuable for analytical work, like silica determination in steel, etc., where hydrochloric acid is used; (3) silica in glass seems to give resistance to water and acid but not to caustic or carbonated alkali; (4) boric acid, up to about 12 parts per 100 silica, increases resistance to water but lowers resistance to alkali and acid; (5) lime is, in general, not an important ingredient and should be avoided if the glass must be resistant to sodium carbonate; (6) large amounts of alkali are to be avoided because they lower resistance to water, alkali and acid; (7) alumina seems a valuable constituent in resistance glasses; (8) zinc is in high favor but specific proof of its value has not yet been shown; (9) the value of magnesia is not known but good glasses do contain considerable magnesia.

C. H. KERR.

German glassworks in March and April 1919. S. N. JENKINSON. *J. Soc. Glass Tech.* **3**, 144–7 (1919).—Before the war, 75 per cent of Germany's glass products were exported. In 1913 her exports were valued at 123 million marks, compared with 103 for toys and 94 for pottery. In the early stages of the war the glass industry was practically stopped but toward the end of 1915 some glass work was started again. Preference was given to factories in small towns where there would be no competition with munitions factories for labor. Prices were exhorbitant and profits were divided with the owners of shut-down plants which enabled all plants to be kept in good repair. In March and April, 1919, orders were plentiful, prices good, skilled labor available, and no stocks on hand, either at the factories or with merchants. But the business was practically at a standstill. For example, in Saxony only 8 out of 117 furnaces were operating. There is no coal to be had, and the same is true of all raw materials, foods, clothing, etc. No glass will come out of Germany for a long time, probably years, but the plants are kept in excellent condition. C. H. KERR.

Glass industry of North America. W. E. S. TURNER. *J. Soc. Glass Tech.*, **3**, 166–199 (1919).—In Canada, glass making is confined to the region of the Great Lakes, at Montreal, Toronto, Hamilton, Thorold and Wallaceburg. In the U. S. the development has largely followed the discovery of natural gas wells. Different branches of the industry are somewhat as follows: Fine artistic glass in New York, lamp-blown and graduated scientific apparatus in southern New Jersey, window and plate glass in Pennsylvania and West Virginia, bottles eyerywhere. For decolorizers, MnO_2 is satisfactory, provided oxidizing conditions can be maintained; but this can be fully accomplished only in closed pots and in the presence of an oxidizing agent such as nitre. In tanks the conditions are reducing, and under such conditions selenium is much better. Decolorizers using selenium as a base usually contain white arsenic and a very small amount of cobalt or "powder blue." Since selenium is not a decolorizer under oxidizing conditions nitre must be absent from the batch. Consequently MnO_2 must still be used with lead glasses. Batch mixing machines are widely used and with good results. The natural gas used at glass works has 1000–1100 B. t. u. per cubic foot, against 150 for ordinary producer gas. The Frink and the Chowning regulators to control gas flow are in process of development. The Owens Bottle Company regard 17 square feet at the melting end of the tank per ton of glass melted daily as standard practice. At some plants this is greatly exceeded. At one plant 1 ton per 11 square feet and at two others 1 ton per 8 square feet were found to be satisfactory. Tank depth varied considerably from 3 to 5 feet. H. L. Dixon regards $3^1/_2$ feet as most suitable in general. Window glass tanks seem to be consistently deeper than other tanks and in the plants visited the depth was about 5 feet. Tank furnaces only 10 feet wide were found to be too narrow, the regenerators becoming overheated. Usually the breadth is about two-thirds of the length. Tank blocks in America show

considerably greater life than those in England. There are three chief causes—(1) the use of soda ash in the batch—in window glass plants where salt cake is used the life is only about 6 months; (2) the use of less CaO in American glass; (3) cooling by air or water. In pot furnaces the universal practice is to use regenerators. Some 20 years ago there was a craze for recuperators but they were not successful. Day tanks are quite common, usually being employed for special purposes, such as the melting of comparatively small quantities of resistance glass. Pyrometers are used in practically every American factory in marked contrast to their absence in English factories. Although there are some hand-operated plants, America is preeminently the home of machine-made bottles and jars. The Owens, Graham (or Owen's A. W.), Hartford-Fairmont Wide Mouth, O'Neill, W. J. Miller, Edward Miller, Lynch No-Boy, Cox, and other machines are briefly discussed. Semi-automatics are also referred to. In electric light bulbs, 3 large companies make 200,000,000 per year. Both hand and machine methods are used. American hand practice with a shop of three men is not equal per operator to the English production where the worker gathers, marvers and blows. Machine production seems destined to replace the hand-work. The Westlake machine is most prominent but it may be superseded by something simpler. Some details regarding the making of glass tubing and rod, chemical and scientific glassware and optical glass are given. In refractories the tendency seems toward thinner tank blocks. Blocks as thin as 8 inches are giving good service, usually with the aid of cooling devices, either air or water. The absence of German clay in America is, in many plants, regarded as a great handicap but in many cases American clays give excellent results. In pot drying great attention is now being given to humidity. American factories are employing chemists and physicists at a greater rate than in England. Colored glass for artistic ware is much inferior to the English and not in great demand. The sheet glass process of the Libbey-Owens Window Glass Company, at Charleston, West Virginia, is in successful operation. C. H. KERR.

Great Britain, glass trade in. London *Daily Mail*, Feb. 3rd.—British makers are laying themselves out to meet the demand for glass and big strides are being made, but notable extensions of plant are hampered by building difficulties. Even the largest firms in the north of England can not keep pace with the orders. Both bottle and sheet glass makers are establishing themselves strongly in the south. The largest of these, the Willesden Glass Co., Ltd., has a first unit in operation capable of an annual output of 10,000,000 square feet of sheet glass. Big extensions, to include machinery, as experience warrants, are under construction. The Belgian hand-blown process is being used with 20 per cent of skilled Belgian workers. British apprentices are being taken on. Most of the present output is for home buyers, but exports are going as far afield as Siam and China. Besides Great Britain's demands it is estimated that France will have to import about 200,000,000 square feet of sheet glass per annum for some years to come. Meanwhile Great

Britain is importing large quantities of glass, especially American tumblers and bottles. The table glass trade on the Tyneside still flourishes and extensions are proceeding at Gateshead. A. J. LAMBERT.

Glass for white flint medical bottles. *Schnurpfeil's Review for Glass Works*, **3**, No. 34, 535 (1919).—Sand 100, carbonate of soda 32, saltpetre 2, lime 24, arsenic 0.5, manganese 0.25. R. J. MONTGOMERY.

Lead glass, dark green of best quality. *Schnurpfeil's Review for Glass Works*, **3**, No. 34, 535 (1919).—Sand 100 pounds, potash 33 pounds, nitrate of potash 6 pounds, red lead 55 pounds, bichromate of potash 10 ounces, oxide of copper 20 ounces, oxide of iron 12 ounces. R. J. MONTGOMERY.

Lead, solubility of, in fritted glasses. *Schnurpfeil's Review for Glass Works*, **3**, No. 34, 539 (1919), from Keram Rundschau.—The solubility of lead in fritted glasses was studied. 817 silicate frits and 560 boric acid silicate frits were tested in a 4 per cent vinegar solution. In lead silicates the resistance to the reagent increased with the silica content up to PbO-2.5 SiO_2, between which and PbO-3.75 SiO_2 it diminishes, rising again beyond that stage. Only frits containing solely lead, alumina and silica were vinegar-proof, although a number of others were very good. Frits containing boric acid but no alumina were very soluble. Zinc substituted for alumina increases solubility.
R. J. MONTGOMERY.

Philippine raw materials for glass making. T. DAR. JUAN. AND V. ELICANO. *Philippine Journal of Science*, **14**, 465–79 (May, 1919).—Attempts made some years ago by private concerns to make glass from materials found in Pampanga and Tarlac resulted in failure. In the Philippines there is now only one glass factory, a bottle plant, which runs intermittently and falls far short of supplying the demand. This plant is at Santa Ana, Manila, and only cullet is melted. There is a large demand for bottles, glasses, and lamp chimneys which is met by imports from Japan chiefly. Deposits of limestone and sand have been investigated and analyses show an abundance of good limestones and some good sand available. The quartzose beach is sand believed to be the best. Alkali would be obtained by the evaporation of sea water. A large number of experimental glass batches, using only native materials, were made up and bottles thus produced were found to give satisfaction in service. In considering the establishment of a glass works here the following should be considered: (1) Coal is expensive but coconut shells may prove practical as fuel; (2) skilled labor would be very scarce and machine methods therefore most desirable—possibly glass blowers from Japan might be brought in more economically. The Bureau of Science in Manila will gladly give any possible help. C. H. KERR.

Refraction of transparent solids, indices of. CH. FABRY. *Jour. De*

Phys. **9,** 11 (1919), from *Amer. Jour. of Science,* **19,** No. 290, 148 (1920).—An immersion method is described by which the indices of refraction for monochromatic light may be measured to one or two units in the fifth decimal place on specimens having surfaces which may not be modified or which are unpolished and irregular. R. J. MONTGOMERY.

Research in glass, the year's progress under the auspices of the Glass Research Delegacy. W. E. S. TURNER. *J. Soc. Glass. Tech.* **3,** 132–44, (1919).—The report is for the year ended March 31, 1918, the third year of the Delegacy. There has been much difficulty in securing funds and suitable accommodations to carry on the work. During the year 151 cases of inquiry have been handled, including 80 that required no experimental work, 58 that required the examination of raw materials and the study of problems in glass manufacture and 13 that involved determining physical properties of glass. The educational work is proceeding well in spite of the handicaps.
C. H. KERR.

Tank furnaces, note on the preliminary firing of. ELBERT E. FISHER. *J. Soc. Glass Tech.,* **3,** 147–8 (1919).—The author recommends maintaining the empty tank at the highest possible temperature prior to charging. This favors the development of sillimanite in the blocks and increases resistance to corrosion. An actual schedule of heating follows: Aug. 12, light fire in checkers; Aug. 13, light fires in side burners; Aug. 15 (6 A.M.), 200° F.; Aug. 16, 350°; Aug. 17, 500°; Aug. 18, 700°; Aug. 19, 900°; Aug. 20, 1125°; Aug. 21, 1350°; Aug. 22, 1550°; Aug. 23, 1775°; Aug. 24, 2000°; Aug. 25, 2200°; Aug. 25 (6 P.M.), 2650°; Aug. 26, 2700° F. Filling in with cullet was then started, followed by batch and cullet as usual. The size of the tank was, melting end, $20^1/_2 \times 14$ feet inside; output, 40–45 tons per 24 hours. Heated up in this way the life is several months greater than when cullet is added prior to heating. C. H. KERR.

Glassworks furnaces and gas producers, some recent improvements in the designs of. J. S. ATKINSON. *J. Soc. Glass Tech.,* **3,** 148–166 (1919).—The Chapman agitator for producers has proven very satisfactory and much superior to producers without mechanical agitation. The advantages of the Chapman are (1) from 50 per cent to 100 per cent increased producer capacity; (2) gas of more constant B. t. u. value is made; (3) the calorific value is increased at least 10 per cent; (4) hand poking is practically eliminated; (5) total labor requirements are greatly decreased—it is often possible to reduce by one-half the number of producers required; (6) the uniformity of the gas permits close regulation of furnace air supply and a minimum of excess air. The Stein type recuperative pot furnace has been very successful at Joudaille and Triquet's works, near Paris. The furnace is described and illustrated. An 8-pot furnace costs $7,000–$8,000, excluding gas producer. Fuel consumption was 37–46 per cent of the weight of glass melted.
C. H. KERR.

PATENTS

Sheets of glass, method and apparatus for drawing continuous. J. P. CROWLEY. U. S. 1,328,268, January 20, 1920. Molten glass flows from a tank to an adjacent shallow drawing chamber in which is mounted a gathering roll, preferably of clay. This roll, which is partly immersed in the glass, rotates and carries with it for about a quarter revolution a film of glass which is fed off horizontally through rollers.

Glass-molding apparatus. E. T. FERNGREN. U. S. 1,328,273, January 20, 1920. Molten glass is fed from a tank outwardly and downwardly through a duct, the upwardly disposed outlet orifice of which is below the level of the glass in the tank. A rotary mold-carrying table moves over this orifice in such a manner that successive blank molds are filled as their bottoms register with the orifice; the glass being forced upward because of the hydrostatic pressure of the molten glass. When large articles are being molded the rotation of the table is step-by-step, but in the case of small articles the flow of the glass is rapid enough to permit of constant rotation. As the blank is carried by the table the blank mold sections are automatically removed and the mold sections proper positioned about the blank. An orifice is then forced down on the blank and the articles blown. It is then automatically discharged upon a conveyor.

Glass bulbs, method of sealing. A. J. LOEPSINGER. U. S. 1,328,530, January 20, 1920. Frangible glass bulbs containing gases dissolved in liquids designed for use in sprinkler systems have their necks sealed without driving off the gases from the solution by immersing the bulbs during the sealing operation in a heat-conducting liquid such as water or mercury.

Glass-drawing apparatus. H. K. HITCHCOCK. U. S. 1,328,673, January 20, 1920. This is a combined drawing and take-down apparatus. It comprises a tilting frame pivoted near the bath of glass from the upper end of which the bait is raised. Air is supplied to the bait through two jointed hollow arms. When the cylinder is drawn the frame swings about its pivot and brings the cylinder into a horizontal position.

Glass, paddle or plunger for molten. H. E. PEILER. U. S. 1,328,799, January 20, 1920. A body of refractory clay is reinforced by a metallic core. This core is kept cool by circulating air or other cooling fluid through passages therein.

Staining glass, method of. J. W. HASBURG. U. S. 1,328,833, January 27, 1920. Glass or ceramic ware is stained by applying a porous foundation coating to the surface thereof, then applying a coloring material upon this coating in a condition which permits it to penetrate the coating and firing.

Sheet glass, apparatus for making. J. WHITTMORE. U. S. 1,328,864, January 27, 1920. One method of making sheet glass consists in drawing the glass upwardly fr m a pool in a continuous sheet and over a binding roll of wood. In order to prevent overheating of the roll, moisture is supplied continuously to its surface by running it in a trough of water. It has been difficult to apply this moisture uniformly, however; drops have collected on the roll, which have turned to steam under the glass sheet, causing irregularities in the finished glass. To obviate this objection this inventor places a suction box along the surface of the roll between the water trough and the point where the glass sheet contacts. This suction box removes the excess moisture and leaves it uniformly distributed.

Glass cylinders, apparatus for drawing. H. J. WALTER. U. S. 1,329,065, January 27, 1920. Grooved guides are provided immediately above the glass to direct the movement of the bait which is flexibly suspended from the hoist cable, and prevent lateral or swaying movements when the bait is entering or leaving the glass.

Glassware, machine for making hollow. S. D. OLSEN. U. S. 1,329,253, January 27, 1920. This is an automatic hollow article or bottle-blowing machine in which the blank is formed in one mold and thus transferred to a blow-mold for the final shaping. These molds are arranged upon a rotary table which rotates with a step-by-step motion. This invention relates particularly to the automatic means for effecting the transfer of the blanks from the blank-molds to the blow-molds.

Glass, apparatus for manufacturing articles of. W. J. MILLER. U. S. 1,329,624, February 3, 1920. This machine for pressing glass articles comprises an intermittently rotating mold support having means for locking it between movements; means for discharging the finished glass articles from the molds, and means for supporting the molds during the pressing or forming operation so as to relieve the mold support and its associated mechanism from strain.

Glass, machine for cleaning blow-pipes for. A. A. KRIDER. U. S. 1,329,841, February 3, 1920. Blow-pipes are fed transversely of a rotor having cutting blades which removes the glass from the ends of the pipe.

Glass-discharging mechanism. J. RAU. U. S. 1,329,851, February 3, 1920. Discharge of molten glass from the spout of a glass tank into molds is effected by having a reduced discharge chamber with a suitable mouth or discharge outlet into which chamber the desired quantity of glass is suddenly forced from an adjacent chamber by means of plunger, which causes glass in discharge chamber to rise very suddenly and overflow into the waiting mold.

Glass cylinders, apparatus for drawing. W. E. SLOPPY. U. S. 1,330,097, February 10, 1920. Means are provided which act automatically to supply air in increasing volume and under a constant pressure during the drawing operation. At the beginning of the draw and during the period in which the cap of the cylinder is to be formed, the apparatus may be manually controlled so that any desired degree of pressure may be produced within the cap in causing expansion thereof to the desired diameter.

Quartz glass, method of building up objects of. W. S. QUIMBY AND F. W. ROBINSON. U. S. 1,330,611, February 10, 1920. A heated nucleus is brought into contact with a mass of quartz powder, and rotated therein so that an accretion of powder is caused to surround and adhere to the nucleus. The whole is then reheated to fuse the powder and incorporate it with the nucleus. During this operation the plastic work is elongated. If the article is a tube compressed air is used as an internal support for the walls.

Glass-blowing machine, automatic. F. R. HOFFSTATTER AND F. J. RIPPE. U. S. 1,330,70 , February 10, 1920. This is a machine for blowing small incandescent lamp bulbs from glass tubing. Successive portions of the tube are automatically fused and blown and the completed bulbs detached and the ends of the tube shaped for the formation of the next one.

Glass-working machines, adjustment and indicator for. W. H. HONISS. U. S. 1,331,467, February 17, 1920. The machine illustrated is one having a paddle or plunger which is swung back and forth and raised and lowered in the molten glass in the outlet spout of a melting furnace to cause he molten glass to flow intermittently from the discharge end of the spout. Means are provided for varying the amplitude and dip of this paddle and indicating means for showing the degree of adjustment. G. E. MIDDLETON.

Glassware, mold for. K. E. PEILER AND W. A. LORENZ. U. S. 1,331,471, February 17, 1920. This is a sectional mold for glassware which may be swung open and closed with one hand.

Glass-shaping machines, transfer mechanism for. K. E. PEILER AND E. H. LORENZ. U. S. 1,331,472, February 17, 1920. Several sets of molds are carried on a rotatable table, each set comprising a blank mold and a blow mold for shaping the bottles or other ware. The blanks or parisons are formed in a blank mold, and then automatically transferred to an adjacent blow-mold in which the bottle is completed.

Method of and apparatus for drawing sheet glass. I. W. COLBURN. Reissue 14,794, January 27, 1920. Original 1,160,692, November 16, 1915. G. E. MIDDLETON.

Whiteware and Porcelain

Apatite substituted for bone ash. B. N. DAVIS. *Trans. Ceram. Soc.*, **18**, Pt. II, 378–381 (1919).—Tests were made with typical bone china bodies substituting apatite for bone in the following proportions:

	1	2	3	4
Apatite	42	39	35	32
Feldspar	15	16	17	19
China clay	33	34	34	35
Flint	10	11	14	14

The material was ground for from ten to forty-eight hours in a ball mill, and worked by casting and plastic methods into a series of test cups. It showed excellent casting properties and plasticity, both being improved by the lengthening of the grinding period. The bodies were burnt to cones 8, 9 and 12, and greatest translucency was developed in 4 at cone 9. All pieces at cone 12 showed deformation and bloating. In color the ware had a slight greenish tinge, giving it a certain distinction. Similar results were obtained in tests carried on by another worker with bodies in which no flint was used. In the discussion emphasis was laid on the fact that working with small trial pieces is not very satisfactory for bone china bodies, since compositions that give good results in small pieces are very liable to warp and deform when made up into commercial wares.

A. J. LAMBERT.

Bodies, notes on the preparation of. R. L. JOHNSON. *Trans. Ceram. Soc.*, **18**, Pt. II, 321–326 (1919).—Comparison of cylinder versus pan milling of flint. It is quite possible to produce equally as good finished material from cylinders as from pans. The amount of steam used per ton of flint ground is higher in the case of pans, partly because the load with cylinders is more uniform and partly because the gearing absorbs more power. Liability to breakdown is considerably higher and more serious in a pan mill. The labor and management cost under equal conditions is greater in the cylinder mill, but this is generally counter-balanced by the cylinder mills having more labor-saving appliances. For cylinders it is preferable to crush the flints to the size of beans, but this is unnecessary for the pans. In capital outlay, the cylinder mill has the advantage. The cost of grinding on a pan mill is not more than the cost of obtaining the same degree of quality and fineness by grinding on cylinders. Where the standard is less finely ground finished material which can be obtained by lawning, the cylinder methods will be the more economical. The higher percentage of milled materials and the finer they are ground the whiter, freer from specks and the more china-like will be the body, speaking generally. Both ball and china clays should be blunged to a thick slip, but not overblunged. The flint and stone ought to be washed fine and aged as much as possible in a slip state and used for mixing in the body at not less than 32 ounces to the pint. Scraps should be added in a slip which is heavier to the pint than the newly mixed body. A. J. LAMBERT.

Bone china body, recent research on the. J. W. MELLOR. *Trans. Ceram. Soc.*, **18**, Pt. II, 497–509 (1919).—There is also a reaction between water and bone-ash which forms soluble acid calcium phosphates, or even phosphoric acid itself. As a result of these changes, the body materials acquire a far greater plasticity than they would otherwise possess. The longer the materials have been associated with water during their preparation, the more "buttery" the body. Bone-ash commences to break down and give off P_2O_5 gas at a temperature about 20° C above what the fireman regards as a good finish. There is not very much more than one or one and a half per cent of iron in a bone china body, but if we find in a bone china body indications of the formation of greenish blue, blue, and brown colors, there is a probability that iron phosphate has been formed. The presence of carbon and insufficient air in the oven favor the formation of iron phosphate by enabling the transformation to take place more quickly at a lower temperature than it otherwise would do. Steam from damp saggars, etc., may act in the same way by preventing the access of air to the ware at the right time. Bone-ash may contain carbon under such conditions that it does not burn out readily. Another form of carbon burns out of the body readily, and gives very little trouble in the biscuit firing. The greenish blue color can be obtained at the ordinary temperature of a china biscuit oven, altogether apart from the atmosphere and of carbon. The range of good body composition is very narrow, being close to 47 bone-ash, 23 china clay, 30 Cornish stone. There is a bigger margin of safety with variations in the proportion of bone than there are in the proportion of either stone or clay. The smaller the proportion of stone and the greater the proportion of clay, the greater the tendency to produce blue or brown china. But by raising the stone too much, the bodies are made to blister or bloat. The mere change from a soft to a harder vari ty of stone may give a perfect body a tendency to form blue china; or the converse change from a hard to a softer variety may make a perfect body liable to blister. A variation in the proportion of water in the same variety of stone may also upset the balance. The same body may produce blistered, blue and perfect china. The blistered body signifies too much stone or too soft a stone, and the blue china too little or too dry a stone. Blue china may oxidize in the enamel kiln and produce brown stains. The condition of the white iron phosphate in the body may be so sensitive that it oxidizes to the brown form merely by exposure to the air. Brown ware is very liable to spit in the enamel kiln. The spits are particularly prolific where the brown occurs, but not in the blue parts. The region for a satisfactory body is very restricted, being bounded one side by the zone of crazing, and on the other by a zone of blistering or bending. A. J. LAMBERT.

Borates of lead, note on the. H. V. THOMPSON. *Trans. Ceram. Soc.*, **18**, Pt. II, 510–11 (1919).—Lead polyborate, $2PbO, 3B_2O_3, 4H_2O$, cannot be obtained by precipitation of a lead salt with borax in excess as stated by Soubeiran, (*Jour. pharm. chim.*, **11**, 31 (1825)). It is doubtful whether there

is such a compound. $Pb(BO_2)_2H_2O$ is precipitated from solutions of lead salts by concentrated borax solution in excess and not $2PbO.3B_2O_3.4H_2O$. The existence of $PbO.3B_2O_3$ as a fusion product of lead oxide with excess B_2O_3 was confirmed. A. J. LAMBERT.

Casting of heavy pottery. B. J. ALLEN. *Trans. Ceram. Soc.* **18,** Pt. II, 363–377 (1919).—Cored or open molds are fitted with airtight casings arranged so that the air can be removed from the space between he plaster and the casing by means of an air pump. If the thickness of clay is abnormal, or a quick casting is required, pressure may be applied to the slip in addition to the vacuum. Here the funnels are fitted with full bore stop-cocks and reservoirs through which the slip passes to the mold and below the stop-cocks a connection to an air compressor. When the mold has been filled and working for a short time under vacuum the stop-cocks to the funnels are closed and compressed air admitted to the top of the slip. The advantages of applying compressed air to one side molds is not so important as its application to cored molds. When articles with both thick and thin parts are to be cast the pressure is applied at the thin parts. The pressure forces the clay slip through the thin part and keeps the way open until the h avy part will take no more, then fills up to the inlet feed and makes a sound piece. This type of mold is very suitable for lining the inside of a refractory pot with special material. For example, zirconia may be cast on the core by dipping, and then placed in the outer mold and the fire clay or other refractory mixture cast on it. In casting a covered glass pot the vacuum chamber at the sides only extends a short distance from the bottom. The object is to permit of the base and sides near the bottom being cast thicke than the top. The superfluous slip from the mould is sucked out by a vacuum pump. The vacuum process can be simplified and made adaptable to various sizes of articles by the use of a vacuum box. The molds are constructed with a framework of wood arranged with runners so that the mold can slide into the vacuum box like a drawer into a chest. The joint at the front is made with a soft rubber washer tacked to the case. This arrangement permits a number of molds being put into one vacuum chamber. A 38-inch glass pot can be dealt with in a similar way, but in the case wheels would be fitted to the bottom of the mold to permit easy withdrawal. In casting enameled fire clay lavatories under vacuum, the white engobe can be filled into the mold and cast up to any desired thickness, then the superfluous material run off and the fire clay run in and cast up solid. In the case of a bath mold a ferro-concrete chamber with metal front and door are used, and the mold supported on "T" iron bearers which act as runners. The plaster mold is framed in wood having suitable apertures to expose the plaster and does not vary much from a mold for pressing baths as far as the outside mold is concerned. When cast up the mold is withdrawn and the core removed, then the front and side molds, leaving the bath resting on the base mold. For casting insulators in multiple molds by the vacuum process a two-piece plaster mold is used and the cores, with

screw thread complete, are of porous pottery, also cast. The cores need not be porous if a high vacuum is used. Specially designed metal cores with a plaster filling may be used. The advantages of the vacuum process for certain refractories is that it is possible to get a density under vacuum and pressure that is impossible by ordinary pressing or by casting without a vacuum. The great advantage, especially for high tension insulators, however, is in the homogeneous structure produced. A. J. LAMBERT.

Nigerian pottery. D. ROBERTS. *Trans. Ceram. Soc.*, **18,** Pt. II, pp. 340–353 (1919).—The use of the potter's wheel and spinning cone have either been lost or were never known amongst the natives of West Africa, although almost every town has its potters. For shaping, an open vegetable gourd or calabash is selected according to the size of pot required and the purpose for which it is intended. To make the bottom part, a piece of clay is batted on and then allowed to dry until the next day, when it is turned up and the top part built to completion. The firing is done in the open. A mound of clay pots intermixed with dried leaves, faggots, wood, corn-cobs, etc., is burnt off in about 12 hours. Those pots which are intended for cooking purposes are dressed while still hot with a liquid preparation made from resinous leaves; this treatment makes them fairly watertight by sealing the pores of the ware.

A. J. LAMBERT.

Brick and Tile

Lime hydrate for chimneys. M. BULNHHIM. *Tonind.-Zeit.*, **44,** 113–114 (1920).—The purpose of this investigation was to compare the compression and tensile strengths of mortars containing Portland cement with those not containing cement. A mortar composed of 1 part lime and 4 parts sand was compared with another composed of 1 part Portland cement, 2 parts lime and 7 parts sand. The results which are tabulated below show that the mortar containing cement is superior with reference to strength.

	Tensile strength kg./cm.²				Compression strength kg./cm.²			
	7 days	28 days	1 year	2 years	7 days	28 days	1 year	2 years
Mortar No. 1 (no cement)	0.31	0.42	1.62	3.90	1.08	1.22	6.23	7.66
Mortar No. 1 (with cement)	1.90	2.37	4.15	4.46	8.30	14.02	42.88	49.16
Brick work with No. 1 mortar	..	..	..	..	134.75	135.40	154.15	160.35
Brick work with No. 2 mortar	..	..	..	..	208.80	228.05	279.50	288.95

H. G. SCHURECHT.

Hollow block question, the solution of the. *Tonind.-Zeit.*, **44,** 75–76 (1920).—Hollow block have not been very popular, due largely to the fact

that too much mortar is required in laying them. An auger machine which will make hollow blocks, closed on all sides, has recently been invented. This auger machine works continuously, making 15,000 brick per eight-hour day. H. G. SCHURECHT.

Rough tile for walks. B. L. *Tonind.-Zeit.* **44,** 95 (1920).—It was found that in many cases the tile used for sidewalks became very smooth and slippery especially in rainy weather. To make a rougher brick coarse grains of grog were added to the tile in making them. These tile had an extremely rough surface at first but after some time also became smooth and slippery. It was observed that porous tile became less slippery than the hard burned tile but these did not withstand the action of frost. It was therefore recommended that a mixture of soft and hard-burned grog be added to the body in making sidewalk tile. Such a tile would wear unevenly and hence have a permanent rough surface. H. G. SCHURECHT.

Standardization of brick. *Tonind.-Zeit.*, **44,** 93–94 (1920).—Building brick constitute burned brick made of clay, argillaceous earth, clay partly replaced by sand, broken quartz or calcined clay. They must have a crushing strength of at least 100 kg./cm^2. These brick are classified as follows: (*a*) Clinker having a compression strength of 350 kg./cm^2.; (*b*) hard burned brick having a compression strength of 250 kg./cm.^{2}; (*c*) building brick, class 1, 150 kg./cm^2., and (*d*) building brick, class 2 having a strength of 100 kg./cm^2. The size should be 25 cm. long, 12 cm. wide and 6.5 cm. high. If it is impossible to make the brick this size the ratio of length, width and height should be 4 : 2 : 1. The limit of absorption for clinker should be 5 per cent hard-burned brick 8 per cent and for class 1 and 2 of building brick the upper limit of absorption is not limited but as a rule it is above 8 per cent. All brick should stand the freezing test. In this test the brick are frozen 25 times in water to —4° C for a period of 4 hours. H. G. SCHURECHT.

PATENTS

Brickmaking machine. C. CROUCH. U. S. 1,331,323, February 17, 1920. A series of brick molds are connected by an endless flexible chain and passed in a vertical plane intermittently beneath a hopper of plastic clay. As each mold is positioned beneath the orifice of the hopper it is provided with a pallet; clay is forced into the mold by means of a plunger, and the mold then moved on to the next position. A second plunger thereupon extrudes the bricks still upon the pallet, which, being yieldingly supported, descends with the plunger and bricks, and the whole is carried off down an inclined runway. Meanwhile a second mold is being charged. The molds in the series are normally spaced apart by several links of the chain. There is enough slack in the chain, however, to enable the charging and discharging molds to be in abutting relation. Power is applied through the charging mold which pushes the abutting discharging mold and pulls the rest of the series.

G. E. MIDDLETON.

ACTIVITIES OF THE SOCIETY

New Members Received during April

Resident Associate

Barth, Victor, 128 Bridge St., Great Barrington, Mass., Enameler, Stanley Insulating Company.

Becque, J. H., Pittsburgh, Pa., Industrial Fellow, Mellon Institute.

Bour, Laurence J., Scranton, Pa., President, L. J. Bour Refractories Company.

Brown, Tom, 217 Dock St., St. Louis, Mo., Enameler, Buck Stove and Range Company.

Cooper, George W., Room 608, 19 Liberty St., New York City, Publisher *The Glass Industry.*

Griffith, R. E., 670 Bullitt Bldg., Philadelphia, Pa., Manager Refractories Sales, E. J. Lavino Company.

Guenther, Emil B., 351 S. Negley Ave., Pittsburgh, Pa., Harbison-Walker Refractories Company.

Guthrie, Chester, Hillsboro, Ill., Pottery Foreman, Eagle-Picher Lead Company.

Herrell, Carson, Kokomo, Ind., Secretary-Treasurer, Kokomo Sanitary Pottery Company.

Hogenson, E., Jr., 1421–41 South 55th St., Cicero, Ill., Secretary-Treasurer, Chicago Vitreous Enamel Products Company.

Holstein, L. S., Palmerton, Pa., Chief, Testing Department, The New Jersey Zinc Company (of Pa.).

Hults, Eugene A., Trenton, N. J., President, Ceramic Equipment Company.

Lyon, P. W., 1332 Frick Bldg., Pittsburgh, Pa., Special Representative, American Sheet and Tin Plate Company.

Storey, O. W., Madison, Wis., Metallurgist, C. F. Burgess Laboratories.

Foreign Associate

Bodin, Victor, 6, rue Jean Jacques Rousseau, a Ivry (Seine) France, Directeur du Laboratoire du Comptoir des Fabricants de Produits Refractoires.

Coad, Pryor, E. A., Teddington, England, National Physical Laboratory.

Corporation

Philadelphia Quartz Company, 121 South Third St., Philadelphia, Pa.

U. S. Smelting Furnace Company, Belleville, Ill.

Meeting of the Pittsburgh District Section

The Pittsburgh District Section held its spring meeting in the Chamber of Commerce Auditorium, Pittsburgh, on April 20th, 1920, at 2.30 P.M., Chairman Peregrine presiding.

The Chairman expressed the wish that all members of the American Ceramic Society in the Pittsburgh District be urged to join the Section. A cordial invitation to join this Section is extended to all members of the parent Soeiety in this district. One dollar sent to the Treasurer, Mr. Thomas H. Sant, John Sant & Sons Co., East Liverpool, will assure your being sent notices of future meetings.

The following interesting program was presented:

"A Study of Spalling," R. M. Howe, Mellon Institute.

"Corrosion Tests for Glass Pot Mixtures," D. H. Fuller, U. S. Bureau of Standards, Pittsburgh.

"Pyrometric Practice," Dr. Paul B. Foote, U. S. Bureau of Standards, Washington, D. C.

The discussion on the last paper was led by Professor H. S. Hower, of Carnegie Institute of Technology, and an instructive symposium on the subject was held.

At 6.30 a farewell dinner was given in the Chamber of Commerce dining room to A. V. Bleininger, who is to be transferred to Washington. Hearty tribute was paid by the speakers to Mr. Bleininger as a man, as a scientist, and as a practical aid to the ceramic industries of this district. Dr. Tillotson introduced the toastmaster, Francis W. Walker, Sr., who reminded the Section that Mr. Bleininger was one of the founders of the Society. L. E. Barringer, of the General Electric Company, spoke of Mr. Bleininger's career in college and complimented him on his never-failing kindness. Mr. W. E. Wells told "What the pottery industry thinks of Bleininger," and his remarks left little doubt of the high standing of Mr. Bleininger among the pottery men of this district. Mr. W. L. Smith spoke in behalf of the United States Potters' Association and also paid the highest tribute to Mr. Bleininger.

Everyone present left feeling that the removal of Mr. Bleininger from Pittsburgh is a distinct loss to the ceramic industry as well as to the scientific circles in this section.

C. C. VOGT, *Secretary.*

Meeting of the Chicago Section

One of the most successful meetings ever held by the Chicago Section of the American Ceramic Society was that which occurred at the dinner arranged by the above Section at the LaSalle Hotel, Chicago, on Tuesday evening, April 20.

It happened that the Illinois Clay Manufacturers Association was holding its forty-second annual convention at the same hotel on this day, and the program given by both organizations was of such a nature that papers of interest to the whole attendance were presented.

At the afternoon session of the Illinois Clay Manufacturers Association meeting, a discussion of the forced draft system of burning was taken part in by C. E. Carter of the Peoria (Ill.) Brick and Tile Co., Harvey C. Adams of the Danville (Ill.) Brick and Tile Co., E. F. Plumb of the Streator (Ill.) Brick Co., and R. K. Hursh of the Department of Ceramic Engineering, University of Illinois.

Professor E. W. Washburn presented a talk on "Some of the Factors Involved in the Drying of Clay Wares."

Professor Carl B. Harrop, of the Ohio State University, and Conrad Dressler, of New York, gave a symposium on tunnel kilns, which proved of considerable interest to all those who attended.

"Belts and Bearings" was the title of a paper read by Professor G. H. Radebaugh, of the University of Illinois.

"The Composition of a Paving Brick as Related to Its Rattler Test" was the title of a paper read by Professor C. W. Parmelee, of the University of Illinois.

Following the dinner, at which forty-eight men were in attendance, a program was conducted under the auspices of the Chicago Section of the American Ceramic Society. Mr. H. P. Matzen, of the Carrier Engineering Corporation of Chicago, read a paper on "Humidity Drying." Mr. I. E. Hardy, of the Tiffany Enamel Brick Company, Momence, Ill., addressed the guests on the subject of "The Enamel Brick Industry." Mr. W. E. Gates, Professor C. W. Parmelee, and others also spoke on timely subjects.

Meeting of the Northern Ohio Section

The eighth meeting of the Section was held in Detroit, Mich., April 5th, with the members present assembled at Hotel Statler. In spite of the inclement weather prevailing at the time, about thirty members gathered for a day of inspection trips arranged by the local committee.

The plants of the Jeffery-Dewitt Co., The Detroit Star Grinding Wheel Co., The Pewabic Pottery and the Ford Automobile Co. were visited. At noon lunch was served at the Detroit Athletic Club, as we were guests of the Jeffery-Dewitt Co. After lunch a short business session was held. Dinner was held at the Detroit Athletic Club, and those who wished went to theatres later.

A vote of thanks was extended by the Section to Mr. Riddle and associates of the program committee and to the officers and research staff of the Jeffery-Dewitt Co. for their hospitality and effort in making the meeting so successfull.

CHARLES H. STONE, JR.,
Secretary-Treasurer.

Important Actions of the Board of Trustees

March 25th.—It was voted that no membership list of the Society as a whole, or of any Industrial Division, shall be published or distributed except in the Year Book of the Society, or as otherwise ordered by the Board of Trustees, and that it shall be the duty of the officers of Divisions and of the Society to refer inquiries for lists of members to the chairman of the Committee on Publications, who is in charge of the selling of advertising space in the JOURNAL.

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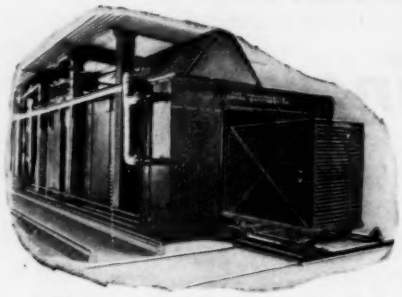

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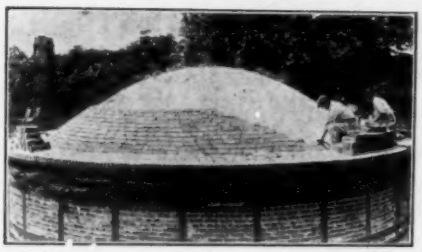

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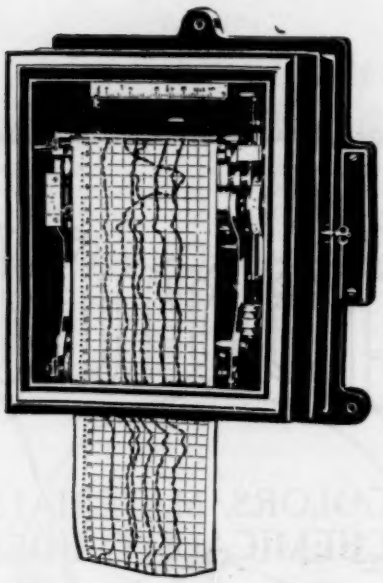

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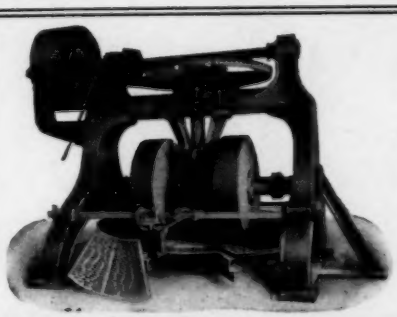

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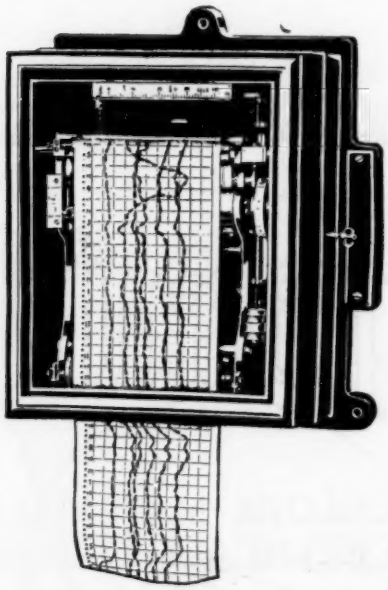

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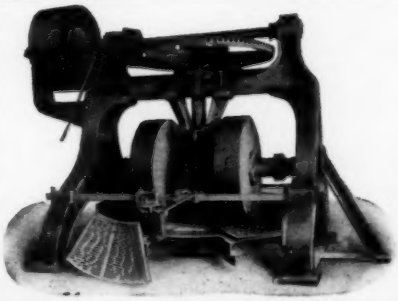

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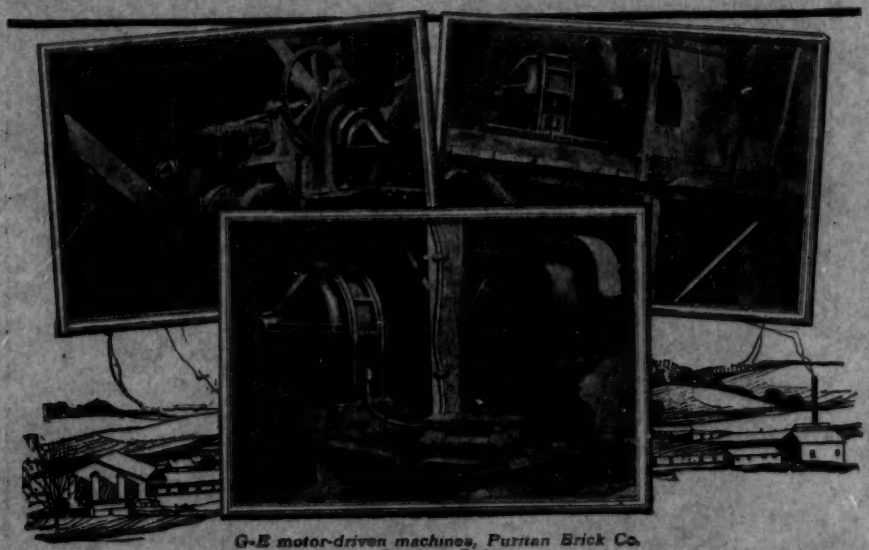

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